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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CI.—No. 2613.] [*Registered at the General Post Office as a Newspaper.*] *LONDON: FRIDAY, JANUARY 28, 1916.* [DOUBLE NUMBER WITH INDEX. PRICE ... 1s. BY INLAND POST .. 1s. 2d.

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See Advertisement page 26. 4960

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PATENTS AND DESIGNS ACT, 1907.

Notice is Hereby Given that

ALEXANDER CONSTANTINE IONIDES, Junior, of 34, Porchester Terrace, in the County of London, Gentleman, seeks leave to amend the Specification of Letters Patent No. 15455, of 1909, granted to him for "Improvements in Heating Apparatus Burning Gaseous Fuel."

Particulars of the proposed Amendment were set forth in the *Illustrated Official Journal (Patents)*, issued on the 19th January, 1916.

Any person or persons may give notice of opposition to the Amendment by leaving Patents Form No. 18, at the Patent Office, 25, Southampton Buildings, London, W.C., within one calendar month from the date of the said Journal.

W. TEMPLE FRANKS,
Comptroller-General. D 428

THE University of Liverpool.

SESSION 1915-16. LENT TERM BEGINS ON 11th JANUARY.

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TENDERS.

BIRKENHEAD UNION.

The Guardians of the Birkenhead Union invite

Tenders from Heating and

Hot Water Engineers for the SUPPLY, DELIVERY, and ERECTION at the Union Institution and Infirmary, Derby Road, Tranmere, Birkenhead, of a COMPLETE CENTRALISED HEATING AND HOT WATER SUPPLY PLANT, together with Mains, Connections and Accessories.

Copies of the General Conditions, Specification and Plans, and Forms of Tender may be obtained from the Consulting Engineers, Messrs. SLOAN & LLOYD BARNES, M.I.Mech.E., 34, Castle Street, Liverpool, on payment of a deposit of Two Guineas, (£2 2s.), which deposit will be returned on receipt of a *bona fide* Tender.

Enquiries (if any) should be addressed to the Engineers. Tenderers are requested to furnish a statement of recent similar work performed.

Canvassing the Guardians, directly or indirectly, will be deemed a disqualification.

Tenders, sealed and endorsed "Centralised Heating and Hot Water Supply Plant," and addressed to the undersigned, must be delivered before Twelve o'clock Noon on 14th February, 1916

By Order,
S. R. CARTER,
Clerk to the Guardians.

Poor Law Offices,
Conway Street, Birkenhead. D 377

INDIA OFFICE, WHITEHALL.
26th January, 1916.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL is prepared to receive

Tenders from such

persons as may be willing to supply:—
SCREW SPIKES.

The Conditions of Contract may be obtained on application to the Director-General of Stores, India Office, Whitehall, S.W., and Tenders are to be delivered at that Office by Two o'clock p.m. on Tuesday, the 22nd February, 1916, after which time no Tender will be received. D 478

G. H. COLLIER,
Director-General of Stores.

CORPORATION OF LEICESTER.

ELECTRIC TRAMWAYS.

The Tramways Committee invite

Quotations for 30 tons of

7 in. STEEL GIRDER TRAMWAY RAILS, to British Standard Specification and of British Standard Section No. 4 C (1½ in. groove), or for Rails of a similar section.

Quotations should be addressed as under, and be delivered not later than Saturday, 5th February, 1916.

E. GEORGE MAWBEY, M. Inst. C.E.,
Borough Engineer.

Town Hall, Leicester.
24th January, 1916. D 440

POWER GAS ECONOMY, LTD.
(IN LIQUIDATION.)

The Liquidator is open to receive

Offers for the Whole Interest

of the above Company in the following Patents:—

Nos. 27678/13, 21327/13, 21328/15, "Improvements in Reversible Regenerative Furnaces."
Nos. 21499/08, 2944/12, "Coke Oven Doors."
No. 8709/14, "Control of Valves."
Nos. 25690/11, 21756/09, 607/11 30072/09; French Patents, 406470, 410588; Belgian Patent, 218787, "Charging Coke Ovens."

Offers are also asked for the Chemical Apparatus, Plans, and other Office possessions (not including furniture) of the Company.

Offers to be sent (by letter) to the Liquidator, JOHN DUNCAN, JUNR., C.A., 140, West George Street, Glasgow, on or before 19th February, 1916.

The Liquidator does not bind himself to accept the highest or any Offer, and does not undertake to give a better title than he at present has. D 446

WESTPORT HARBOUR BOARD.

DOMINION OF NEW ZEALAND.

Tenders for Bucket Dredger

AND STEAM HOPPER:—

Tenders will be received until Noon of 2nd March, 1916, at the Office of the HIGH COMMISSIONER of the Dominion of New Zealand, Westminster Chambers, 13, Victoria Street, London, S.W., for the CONSTRUCTION and DELIVERY of ONE BUCKET DREDGER, and of ONE STEAM HOPPER BARGE, for the Westport Harbour Board, New Zealand.

General Conditions of Contract, outline Specification, Form of Tender, &c., may be obtained by *bona fide* Tenderers on application to the Office of the the High Commissioner, and payment of a deposit of £2 2s. Tenders will be considered only from firms of standing, accustomed to the building of vessels of the kind; they must be on the Board's Form of Tender, and must be accompanied by plans and detailed specifications.

Tenders, which must be separate for each vessel, must be addressed to the Westport Harbour Board, care of the High Commissioner, and endorsed either "Tender for Westport Dredger," or "Tender for Westport Hopper." The lowest or any Tender will not necessarily be accepted. D 443

(Signed) CHARLES GREENLAND,
Secretary.

APPOINTMENTS OPEN.

Wanted, in July next, an

experienced MINE MANAGER, for the East; preferably with knowledge of gold mining, cyaniding and slime filter treatments.—Address (by letter), stating age, to K. C., care of J. W. VICKERS & Co., Ltd., 5, Nicholas Lane, E.C. D 421

CLEETHORPES-WITH-THRUNSCOE URBAN DISTRICT COUNCIL.

APPOINTMENT OF SUPERINTENDING MECHANICAL ENGINEER FOR SEWAGE PUMPING STATIONS.

The Council are prepared to receive

Applications for the above

named POST at a salary of £160 per annum. A knowledge of gas engines is essential.

Particulars may be obtained on application to the undersigned.

Applications, endorsed "Superintending Engineer," must be sent to me, with copies of not more than three recent testimonials, before Five p.m. on the 9th February, 1916. Canvassing will disqualify.

ALBERT S. BARTER,
Clerk to the Council.

Council House, Cleethorpes.
25th January, 1916. D 457

ST. DUNSTAN'S COLLEGE,
CATFORD, S.E.

Wanted, at Once, for this

College, during the war, an ENGINEERING MASTER to take charge of the Technical Side.

Experience in engineering works and in teaching required. Salary £160 per annum.

Apply to C. M. STUART, Headmaster. D 459

Wanted, Thoroughly Experienced and Capable ENGINEER, for War

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Man Wanted (Ineligible),

capable of taking over the clerical work connected with a large Shoeing Forge.—Address, with full particulars, D 454, Offices of ENGINEERING.

Engineer Wanted, with

experience of Time and Motion Study Systems, to assist in re-organisation of Engineering works and also the erection and repair of plant. No person already employed on Government work will be engaged.—Apply, giving full particulars, to nearest LABOUR EXCHANGE, mentioning this Journal, and D 440.

Wanted, Three Shift

ENGINEERS, for power station and special plant in large controlled factory in Midlands. Marine or refrigerating experience an advantage. No person already employed on Government work will be engaged.—Give full particulars, experience, age and wages required, to the nearest LABOUR EXCHANGE, mentioning this Journal, and No. A 1385. D 441

Clerk Wanted, in Engineering

Works, S.E. London, to keep records of piecework prices. One with knowledge of machining operations and able to make up complete piece-work cost of any given article from records. No applications from men eligible for H.M. Forces will be considered.—Write, stating age, experience, and salary required, to nearest LABOUR EXCHANGE, mentioning this Journal, and D 447.

Wanted, for Government

work, in Derby,

CHIEF TOOL DRAUGHTSMAN,

experienced in milling and drilling jigs, and press-tool work.

It is essential that applicants should have had experience in the manufacture of small accurate parts.

No man on Government work need apply.

Apply, stating age, experience, salary expected, and a reference, to the nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and No. A 370. D 341

Draughtsman, with Jig and

tool experience, WANTED for Government Work. Good prospects. No one already on Government work need apply.—Apply to nearest LABOUR EXCHANGE, mentioning this Journal, and D 433.

Draughtsman, (Ineligible),

thoroughly accustomed to design and construction of mechanical waterworks, filters and softening plants in steel and concrete, also apparatus for chemical treatment. Must also be prepared to assist outdoors in erection, charging, adjustment and manipulation. No person already employed on Government work will be engaged.—Write, with testimonials, to nearest LABOUR EXCHANGE, mentioning this Journal and D 405.

Wanted, in London, Draughtsman, for general work; one with shop

experience preferred. Also young ENGINEER, with workshop experience, as junior draughtsman. Candidates must be ineligible for the Army, and no person resident more than 10 miles away or already employed on Government work will be engaged.—Address, stating age, experience, and salary required, D 475, Offices of ENGINEERING.

Draughtsmen.—Wanted, Two

DRAUGHTSMEN, with good technical training and knowledge of strength of materials. Able to determine stresses in structures; experience in aeroplane construction and design desirable, but not essential. No person resident more than 10 miles away or already engaged on Government work will be engaged.—Apply, stating full particulars, experience age and salary required, to THE SOPWITH AVIATION CO., LTD., Kingston-on-Thames. D 476

Boiler Draughtsman Required

for Government controlled firm in the Midlands. Only those not eligible for military service and not already employed on Government work need apply, stating age, salary required and references, to nearest LABOUR EXCHANGE, mentioning this paper and D 408.

BIRMINGHAM MUNITIONS COMMITTEE.

DRAUGHTSMEN.

Several Competent Men

REQUIRED, with first class jig and tool experience.

Apply by letter, stating age, qualifications and salary expected, to

EMPLOYMENT OFFICER,
National Shell Factory, Midland Works,
Washwood Heath, Birmingham.

Mark envelope, "Draughtsman."

No one already engaged on Government work need apply. Those outside 10 miles radius apply at nearest LABOUR EXCHANGE. D 427

Wanted, for Government

work, in Derby, several

ASSISTANT TOOL DRAUGHTSMEN.

Experience in milling jigs, drilling jigs, or Cleveland automatics essential.

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THE INSTITUTION OF MECHANICAL ENGINEERS.

AN ordinary general meeting of the above Institution was held on Friday last, the 21st inst., at the Institution of Civil Engineers, Great George-street, Westminster, the President, Dr. W. C. Unwin, F.R.S., occupying the chair. The meeting commenced at 6 P.M., and judging from the attendance the earlier hour appeared to be popular.

COUNCIL RETIRING LIST.

The first business of the meeting was the announcement by the President of the fact that, in accordance with Article 25 of the Institution, the President, two Vice-Presidents, and seven Members of Council would retire at the ensuing annual general meeting. The list of those retiring was as follows :—President : Dr. W. C. Unwin, of London; Vice-Presidents : Mr. Henry Davey, of Ewell, and Mr. Michael Longridge, of Manchester ; Members of Council : Dr. A. Barr, of Glasgow; Dr. H. S. Hele-Shaw, of London ; Mr. Alfred Herbert, of Coventry ; Mr. Walter Pitt, of Bath ; Mr. Vincent L. Raven, of Darlington (appointed during the year); Captain H. Riall Sankey, of London; and Mr. Wilson Worsdell, of Ascot. All the foregoing, with the exception of Mr. Herbert (who desired to resign), had been nominated, with their consent, by the Council for re-election. The following gentlemen had also been named by the Council, with their consent, for inclusion in the Council ballot-list :—Mr. Bowman Malcolm, of Belfast, Mr. William Reavell, of Ipswich, and Mr. David Evan Roberts, of Cardiff. Following this announcement, the President invited any member to add to the list, but no additions were proposed.

ALTERATION OF BY-LAWS.

Dr. Unwin then observed that a very serious question, arising out of the war, had come before the Council. A number of the members were on active service, and while on such service were scarcely in a position to continue their subscriptions to the Institution ; nevertheless, the Council did not desire to lose those members. Moreover, many members had been seriously affected financially by the conditions of the times. The Council had, therefore, been considering what could be done to retain members of all classes so situated. In view of the fact that the by-laws operated to restrict action, the Council had decided to propose, at the annual general meeting to be held in February next, a revision of the by-laws to meet the cases referred to. To do this, however, it was obligatory upon the Council to state, at the meeting now being held, the exact terms of the proposed alteration of the by-laws. The President then proceeded to read the terms of the proposed alteration, which were as follows. To by-law No. 18, under "Entrance Fees and Subscriptions," it was proposed to add the clause :—

"The Council, at their discretion, and for sufficient reason, and for such limited period as they may determine, may reduce or remit the annual subscription, or the arrears of annual subscription, of any member, associate member, associate, or graduate who, in consequence of his engagement on active service, or on other national war service during the war commenced August, 1914, shall have become unable to maintain the annual subscription provided by these by-laws."

It would be understood, Dr. Unwin continued, that the matter could not be dealt with in any other way, because private inquiries would be needed. The next clause read as follows :—

"If the Council shall be satisfied that any member, or associate member, or associate has during the war resigned his membership, or has been struck off the register, on account of financial difficulty due to the war, the Council may, at their discretion, remit his entrance-fee on re-election."

Dr. Unwin here stated that the Council did not desire to charge a second entrance-fee to a man who had been obliged to resign on account of financial difficulty caused by the war. That would involve an amendment of Article 25, to which Article it was proposed to add the following :—

"Provided always that notwithstanding the provisions of the preceding by-laws, if the Council shall be satisfied that any member, associate member, associate, or graduate has, during the war commenced in 1914, resigned his membership, or has been struck off the register, on account of financial difficulty due to the war, he may be re-elected by the Council"—without having to go through the regular formalities—"as a member in the class of membership in which he was previously to the war, provided that previously to and for the purpose of such re-election he shall have signed the form of engagement or agreement set out in the appropriate proposal form A or B in the appendix."

Mr. A. W. Marshall inquired whether the proposed alteration would affect the question of members coming under it being able to attend meetings and receive the Proceedings, or would the temporary suspension of a member's subscription cut him off from these privileges?

Dr. Unwin replied that this matter would be one for the discretion of the Council. The Council would require to know that the resignation or removal from the register was due to financial difficulties consequent upon the war. Speaking generally, however, he was confident that the Council would desire to be generous in the matter.

Fig. 1.

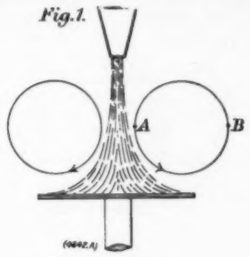
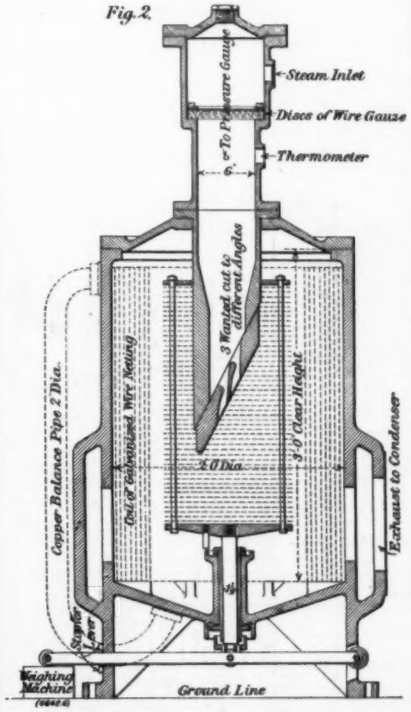


Fig. 2.



FLOW OF AIR THROUGH NOZZLES.

The paper set down for reading and discussion was one entitled "The Flow of Air Through Nozzles," by Captain Thomas B. Morley, B.Sc., Associate Member, of the University of Glasgow. This paper, of which we commence the publication in full in another part of this issue, was read by the author.

Subsequent to the reading of the paper, Captain Morley made a few remarks in relation to a diagram (Fig. 1) exhibited by Mr. H. M. Martin. He said that the flow of air surrounding the jet was normal to the jet, and that normal direction of flow persisted until very close to the plate. Then there was a sudden reversal round about the plate ; to perhaps about $\frac{1}{4}$ in. or $\frac{1}{2}$ in. away from the plate the flow was tangentially upwards, but up till very close to the plate the flow of air was normal to the jet. That was indicated by the smoke-bands and by the threads. He would here mention that some of the experiments made with the pressure tube gave but little evidence in favour of the jet having a parabolic form. The speaker then described the circulation of the air, and went on to say that it was fairly well established that the energy system of circulating air did not make any very considerable demand upon the energy of the jet. It was initiated by the jet, but once set up it demanded only the small amount of energy required to overcome frictional losses. Therefore there approached the plate not only the original air from the jet, but a considerable body of air from the circulating curves ; the momentum of the air deflected by the plate was accordingly increased. As the plate got further away from the nozzle more of the circulating air was taken in, the effect increasing up to a certain maximum. It was not possible for him to give a mathematical demonstration of the system of stream-lines round about the jet, but he had endeavoured to give an outline. What he had done certainly led to a result which was in agreement with the form of the impact variation curves.

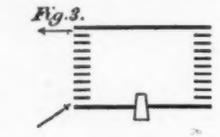
Captain H. Riall Sankey opened the discussion, stating that he regarded the paper as one of special importance. It was really one of a series of papers that had been before the Institution on the question of nozzles, and he would remind the Institution that some time ago a research on nozzles was suggested by one of the members. The suggestion was taken up by the Council, and the first fruit was a paper by Professor Henderson. In discussing that paper Mr. Jude had recommended air as the best substance for experimenting with, so that Mr. Jude and Captain Morley were in agreement on that point. The data given in the author's paper were of great practical value. To the speaker the most interesting matter was the discussion with regard to reaction and impact, because it had a close application to the work about to be done by the Committee of the Institution on Steam-Nozzle Research. At first sight it seemed better to grapple with the substance before parting with it—the reaction method—than to deal with it after it had, so to speak, been let loose in the universe—the impact method. Although it might be said that reaction was the best method of any, the difficulty was to get the substance to the nozzle. Captan Morley had described, in his paper, how this was done for air, and had stated that there was no sensible friction in the long arm on the swivel joint. Whether a similarly good result would be got when dealing with steam was not quite certain, because its temperature, its wetness in some cases, and other factors affected the results. The speaker feared that there would be a certain amount of friction which would not be very definite. In discussing the matter at the Committee meetings, the question of impact and its difficulties had been fully realised, and Mr. H. M. Martin had suggested a means of overcoming these difficulties by surrounding the jet with a cage. Captain Sankey then referred to the wall diagram (Fig. 2) illustrating this cage, indicating the respective positions of cage and nozzle. The idea of the cage, which was made of thin strips of metal, was to prevent the formation of eddies. When the author's paper was in proof, copies had been issued to various members of the Committee, and Captain Morley and Mr. Martin had discussed the matter. Further, Mr. Gerald Stoney had suggested, as far back as November 19 last, that a crucial experiment might be made by having a cage, with a plate at the bottom of it, and at the top a nozzle, the whole being supported on the weighing arrangement which Captain Morley had used. If, then, there were any real difference between the reaction and the impact, there should be a motion at the cage. That experiment had been made, with results which, he believed, Captain Morley proposed to explain. He would like to ask the author one or two questions. Could Captain Morley say if there had been any time lag in the thermometers, and, if so, had any account been taken of it? He had noticed that electrical thermometers had been used, and the lag of those was about one-half of a second, which might be an appreciable amount. Further, did the wire stretched at the bottom of the air-container really give the mean temperature of the air throughout the vessel? Of course, this mean temperature was required for the formulæ in the paper. The volume of the vessel, the author had stated, was determined by running water

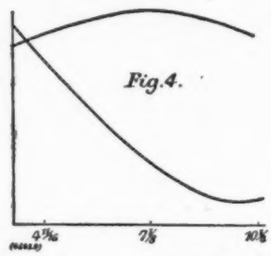
into it. Was it necessary to make any allowance for the water which wetted the side of the vessel? Again, it was stated that the errors in the area A had not affected the discharge, but the speaker did not quite see how that was possible. Later in the paper the author had used the words "the theoretical discharge per unit area of nozzle, as shown in Table III., by the nozzle area." It seemed, however, to the speaker that in the discharge the area must come in, and if that were so, the errors in the area must be of some importance. The author had also stated that "the pressure in the reservoir was noted, with the spindle again just clearing the stops, in the same manner as before." The speaker understood from this that, in the experiments, the pressure was continually varying as the air passed out of the vessel, and therefore that observation must have been somewhat in the nature of a "flying shot." Perhaps Captain Morley would explain what degree of accuracy would be got in that case.

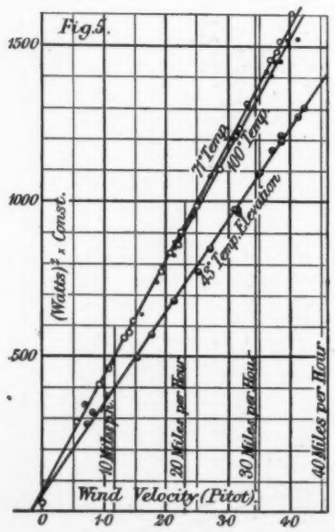
Captain Morley then described the experiments which had been made in regard to the cage. He regretted that he had not obtained such full information as he had hoped for. As he had explained to the Committee at the time when the suggestion was made, his duties had taken him out of Glasgow, and it was quite impossible for him to carry out the experiments personally. He had, however, offered to place his apparatus at the disposal of the Committee, and Mr. R. M. Brown, B.Sc., of Glasgow University, had kindly consented to carry out the experiments for him. The cage supplied by the Research Committee had only been in Mr. Brown's hands eight or ten days ago, and he had brought to the meeting two letters he had received from Mr. Brown relating to the experiments which the latter had made. All that could at present be stated was the general character of the results, from which it appeared that there was not an exact balance between impact and reaction, the impact being slightly greater than the reaction obtained. The speaker then sketched on the blackboard the nature of the cage as supplied by the Committee (Fig. 3). It would be seen that there was provided a top plate and a bottom plate, a series of rings, and the nozzle. The scale of the weighing-machine was below the nozzle, the whole apparatus being mounted vertically. One matter that added to the difficulty of Mr. Brown's experiments was the weight of the nozzle, which made a very considerable addition to the load on the scale-pan, somewhat affecting the sensitiveness of the balance. Mr. Brown had informed the speaker that the balance was a little sluggish in working with this apparatus on. Mr. Brown had found the direction of the circulating currents to be as shown in the sketch by the arrows. The speaker did not know whether the Committee intended the cage to stop the circulating currents; it certainly did not stop the currents; it could only guide them. An interesting statement by Mr. Brown was that at the lower part the direction of flow was slightly upwards, and the air left quite tangential, or practically so, from the top plate (see arrows in sketch). Mr. Brown had also found, with a pressure of 53 lb. per sq. in., a difference of 0.83 oz. between the impact and the reaction; compared with the reaction found and shown in the paper, that represented a difference of about 2½ per cent. Experiments at other pressures had been made with similar results; the impact was in excess of the reaction by about 2½ to 2 per cent. of the value of that reaction. Another interesting point which had arisen related to the experiments Mr. Brown had made with a different distance between the top and bottom plates. The results were indicated by the speaker on the blackboard (Fig. 4), the actual figures not being given. [This constituted a shortening up of the cage, as remarked by Captain Sankey.]

Mr. Brown had found that with a given out-of-balance effect the pressure varied. If the apparatus were balanced, with no air flowing, Mr. Brown added half an ounce. Turning up the pressure till the balance was again just reached, Mr. Brown had found, with the different distances, that the pressure required was at the maximum at the distance of 7⅛ in. That would correspond to the difference between impact and reaction, taking the form shown in the curve. The description above given indicated roughly the nature of the results. The actual figures would not be given, as, from the phraseology of his letter, Mr. Brown was evidently desirous of having time to confirm them.

Professor J. T. Morris, of East London College, desired to confine his remarks entirely to the subject dealt with by the author in his paper under the sub-heading of "Measurement of Velocity." The author had there stated that the methods of measuring the velocity of the air-jets were three in number, namely, the Pitot tube, the measurement of the reaction, and measurement of the impact of the jet upon a surface of known form. The speaker, however, would put forward a plea for the consideration of a fourth method—viz., in connection with the electrical measurement of velocity. Some years ago Boussinesq showed theoretically that there was a definite relation between the amount of energy required to keep a wire a certain number of degrees above the temperature of the air in a wind, and the velocity of that wind. Dr. Kennelly, of the Massachusetts Institute of Technology, publishing in 1909, was the

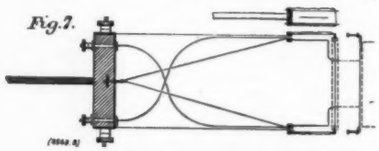




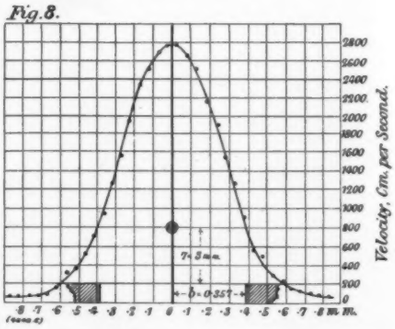


first, so far as the speaker was aware, to demonstrate this theory experimentally. Later on the speaker, who was engaged in a series of aeronautical measurements, was looking round for a rapid and accurate method of determining the velocity of wind, and, after trying various methods, came to the conclusion that the electrical method could be applied with very definite advantage. The first slide (Fig. 5) he would throw upon the screen would show the results of some of his experiments published at the British Association meeting at Dundee, 1912, giving the connection between the velocity and the amount of energy required to keep the wire a certain number of degrees above the temperature of the atmosphere. This slide showed, as the speaker had intimated, by means of a curve, that when the wind velocity, as measured by the Pitot tube, was set out horizontally, then if the square of the watts required to keep the wire at a constant number of degrees of temperature above that of the air were set out, the result would be an absolutely straight line; that had been tested for a number of temperature elevations—from 43 deg. to 100 deg. Cent. The curves, which had been plotted to different scales, were sufficient to show the linear relation between the square of the watts which were required to keep the wire at that excess temperature and the wind velocity. The curve, however, did not strike down to zero exactly, for the reason that when the wire was in still air a certain number of watts were required to keep it at that temperature. That number of watts, however, was small, and if subtracted from the total, and the square taken, a quantity was obtained which was directly proportional to the wind velocity. These tests had only been carried up to wind speeds of 40 miles an hour; but there was good reason to believe that the relation would not be seriously departed from for very much higher velocities.

FIG. 6.



Professor King's anemometer: Details of fork. The wire is shown in position over the end of a channel of rectangular cross-section, and illustrates the guard-ring effect obtained by the use of potential terminals fused to the wires.



The second slide shown was a reproduction of Fig. 10, published on page 180 of ENGINEERING of August 8, 1913, and gave the result of experiments carried out by the speaker in the aeronautical laboratory at East London College, in which the velocity was measured around a circular rod when placed in a 15-miles-per-hour air current. It would be seen that the highest velocity indicated was rather over 20 miles an hour; the wind was blowing vertically downwards.

Another slide, reproduced in Fig. 6, illustrated a portable anemometer invented by the speaker, shown in use on an East Coast lighthouse, where it was tried by permission kindly given from Trinity House. The speaker indicated the position of the apparatus measuring the wind velocity, as also the positions of the battery and the ammeter. He had carried the whole of the apparatus with ease on his bicycle.

In connection with another slide exhibited, the speaker stated that since the work which he had described was published, Professor L. B. King, working at the McGill University, Montreal, had

carried the subject further, publishing valuable papers in the Transactions of the Royal Society in 1914, and in the *Philosophical Magazine*, 1915, and had devised what he termed a "precision linear hot-wire anemometer," using a set of connections familiar to electrical people under the name of the "Kelvin bridge." All that the speaker could say about the matter in the time at his disposal was that a platinum wire was fixed in the air current where the velocity was to be ascertained, and that such an electric current was sent through this wire as to bring the bridge into balance; the fourth power of the current was then—neglecting certain corrections—proportional to the velocity of the air.

The next slide, reproduced in Fig. 7, represented Professor King's anemometer, the speaker indicating the wire, which was of platinum, 2½ to 3 mils in diameter, with two contact-points fused on to it. The length between these two contact-points was the effective part. Captain Morley might very reasonably say that this piece of apparatus would probably not be of any use in his experiments, for two reasons: one, that the velocity of his jets was so high [the speaker noticed that in some of Captain Morley's jets the velocity of sound in air was exceeded]; and the other, that the apparatus only gave a mean value of the velocity over a certain distance. Recently, however, Professor King had used wires on which the contact-points were 0.4 in. apart, and shorter distances could be employed if need be.

Another slide showed a photograph of the apparatus. The wire was at the end of a fork, exhibited, but could not itself be seen on the slide. Professor Morris pointed out the position of a micrometer head, by means of which it was possible to advance the hot wire through measured distances.

Another slide showed some of the results which Professor King obtained for channels or slits. The speaker indicated the section of a slit and the experimental points showing the velocities attained.

The last slide shown by Professor Morris is reproduced in Fig. 8, and illustrated the kind of distribution obtained at a distance of 3 mm. (about ⅛ in.) from a channel whose width was only 0.75 mm.; that was to say, about 0.03 in. This slit was very much narrower than the author's jets, which were about 5 mm. in diameter (¼ in.); therefore the jets would represent about seven times the width indicated in the diagram shown by slide No. 8. The precision shown by the apparatus was so good that it was possible to detect a movement of one-thousandth of an inch. A shift of the wire by one-thousandth of an inch would be amply sufficient to show the change of velocity, and the speaker submitted that if the apparatus in question were employed, a great deal more information with regard to Captain Morley's jets could be obtained. The author had done some exceedingly valuable work in his paper, and he (the speaker) knew too much about experiments to ask Captain Morley to undertake a lot more; but if others were working on the subject, he would certainly suggest that the electrical method of measuring velocity was worthy of careful consideration.

Mr. H. M. Martin remarked that there appeared to be two matters of prime importance established by Captain Morley's experiments. In the first place it would be observed that in all the experiments made by the latter the weight discharged was less than the theoretical. This was quite in accord with what would have been anticipated from past experiments on superheated steam. In all careful experiments made with superheated steam the observed discharge had always been less than the theoretical, whilst with wet steam the discharge had been in excess of what the usual theory demanded.

Experiments on the discharge of steam could, the speaker stated, be made with much precision, owing to the ease with which the steam could be condensed and weighed. As superheated steam showed no such anomalies, he had always distrusted experiments on air in which excessive discharges have been recorded. It seemed incredible that an anomaly of this kind should be apparent with air and yet absent with a much less perfect gas, such as superheated steam. Further, the only feasible explanation advanced of such excessive discharges asserted that a rapid expansion of a gas gave rise to an abnormal partition of the energies due respectively to the spin and to the linear velocity of the molecules.

Were this hypothesis true, the speed of sound in air should be substantially greater than its theoretical value. No such excess had been observed, although, in the case of high notes, the expansion of the wave was effected in less than $\frac{1}{40,000}$ of a second. Moreover, it had been shown by direct calculation that a very abnormal distribution of the linear velocities of the molecules of air would be corrected in less than $\frac{1}{60,000,000}$ second, and there was every reason to believe that an abnormal distribution of spin energies would be corrected in a time of much the same order. In fact, any abnormal partition of energy was corrected practically instantaneously, and could not be responsible for the abnormal discharges sometimes recorded with air, which must, in the speaker's opinion, be attributed wholly to experimental errors. This view was strongly supported by Captain Morley's experiments. He would add that the coefficient of discharge found by Captain Morley was in excellent agreement with certain experiments of Stodola, from which it would appear that the loss of energy in the converging throat of a round nozzle was of the order of 4 or 5 per cent.

The second important point to which Mr. Martin wished to refer was Captain Morley's discovery of the cause of the discrepancy between the impulse and reaction of a jet of air or steam. It has been known for a long time that measurements of the impulse of a jet showed certain anomalies, and the speaker believed that the original discovery was due to Mr. Gerald Stoney. But, so far as he knew, Captain Morley was the first to have traced these peculiarities to their source, and this discovery was of the greatest interest and importance. He had found, in short, that the jet was the centre of a vortex ring, such as the speaker had indicated in the diagram on the wall (see Fig. 1, page 73); but Captain Morley had informed him that the circulation was far more extensive than was there indicated. This vortex originated in an entrainment due to the jet, but once established it appeared to be maintained with very little further abstraction of energy or momentum from the jet. This condition, in fact, was responsible for the erroneous readings found, since, unless the entrained particles kept returning again and again, the entrainment would not affect the total momentum reaching the pressure-plate. Each molecule of air taking part in the circulation was at one moment moving towards the plate, and at a later point in its path was moving away from it. Its momentum had accordingly been reversed. That reversal must be due to a pressure, part of which was borne by the plate and part by the walls of the laboratory.

It was important to note, however, that a similar pressure must also have acted to change the momentum of a particle at B to the momentum at A, and part of that pressure must have been carried by the nozzle, the reaction of which was by so much too high. In Captain Morley's experiments the error thus arising was, of course, so small as to be negligible; but where, as in Christlein's experiments, a large nozzle-plate was used, the error would be quite comparable with what would be experienced with a pressure-plate. Hence, unless the eddies were suppressed, a reaction test was open to an error of the same kind as an impulse test.

In the case of Dr. Christlein's experiments, Mr. Martin did not think that any large circulation could have been established within the confines of the apparatus used by the former. In fact, Dr. Christlein's recorded reactions appeared to be too small rather than too large, but the arrangements made for taking the pressures and temperatures of the steam, both before and after efflux, seemed open to serious criticism. There were some very great practical advantages in measuring impulse rather than reaction. In particular, in an impulse test the whole of the steam connections might be rigid.

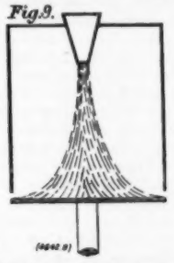
With the permission of Captain Sankey, the speaker had placed on the wall a drawing (see Fig. 2, page 72) showing a proposal for measuring the impulse of a jet which had been discussed by the Nozzles Committee. The plan, it should be added, was submitted and discussed before any of the committee had knowledge of Captain Morley's results. Nevertheless, the one conclusion arrived at was that every effort must be made to suppress eddies, if reliable results were to be attained.

As shown in the diagram, the steam entered near the top, and on its way to the nozzles passed through screens of wire gauze, intended to take out the eddies. After passing the screens it flowed to the nozzles at a low velocity, so that its pressure and temperature could be measured with certainty. On issuing from the nozzle, the jet struck the pressure-plate shown, and was deflected by it into an exhaust belt, which communicated with a condenser. The pressure-plate was surmounted by the cage described by Captain Sankey, consisting of a series of flat rings, spaced a short distance apart, and the top of the cage was closed by a plate which fitted the nozzle-box pretty closely, but without touching it. From Captain Morley's report, it appeared that this cage alone eliminated three-fourths of the error, but additional precautions were provided in the apparatus, which the speaker thought would abolish the residue.

Thus the exhaust-chamber outside the cage was lined with many turns of galvanised wire-netting. It did not seem likely that in these conditions any important circulation could be set up, but it was further intended to provide means for varying the distance between the nozzle and plate whilst the jet was at work. This could be done very simply, and, if the precautions taken were effective, a variation in the spacing between jet and nozzle should have no effect on the impulse recorded. The pin supporting the pressure-plate passed through a bush, which was kept in steady rotation, so as to practically eliminate frictional resistance.

An alternative method of getting rid of the error due to the establishment of a circulation had occurred to Mr. Martin since reading Captain Morley's paper. It is represented in Fig. 9, annexed. Here the nozzle entered an inverted

Fig.9.



cylinder, to which it was firmly secured. The lower edge of the cylinder was brought down close to the pressure-plate. Under these conditions it seemed likely that there would be no room for any extensive circulation to be established.

Mr. W. H. Patchell, Member of Council, referred to a remark by the author to the effect that he was unaware whether turbines driven by compressed air had ever been employed. In this connection the speaker wondered whether Mr. Ferranti had had Captain Morley's paper brought under his notice. The speaker had, unfortunately, not seen the paper in time to submit that gentleman's name to the Secretary; but he believed that Mr. Ferranti had done a good deal of work in the direction just referred to, and it might be an advantage if he were asked to contribute something to the discussion. The author had suggested that, in place of reciprocating engines or motors, air-turbines might be used, where power was transmitted by compressed air, and in the same paragraph had referred to the propulsion of a torpedo by air. That, the speaker said, was not exactly the same thing as was generally understood by "transmission of power by compressed air;" he understood a torpedo to have a vessel of compressed air which it took along with it. Mr. Sam Mavor had read, before the Institution of Mining Engineers, about a year ago, a paper on the efficiency of compressed-air machines, which indicated at different stages the losses of efficiency, and it appeared that these losses were not by any means restricted to the actual machine or motor. In the speaker's opinion it was necessary to look a good deal further afield than the actual motor, in considering the efficiency of compressed air.

Captain Morley then replied to the discussion. In connection with Captain Sankey's remark that he was not quite sure as to the frictionless character of the reaction apparatus as applied to steam, the speaker would say that when he designed his apparatus he was unaware that steam experiments were in prospect; he had designed the apparatus to suit his own case. He quite appreciated the difficulty of using the reaction apparatus for steam, but, as in many other cases, a compromise had

ONE OF THE NEW BRITISH PROJECTILE-MAKING FACTORIES.

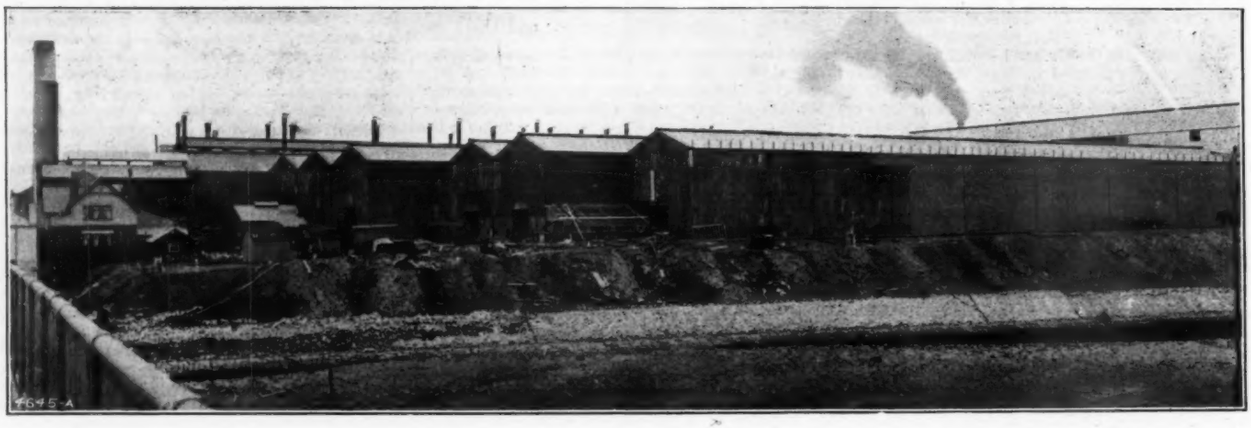


FIG. 1. EXTERNAL VIEW OF FACTORY.

to be achieved. It was possible that the cage arrangement might yet be modified to give certainty of results. He had himself made one suggestion in his remarks on the sketch, when he stated his belief that the upward velocity of the air, shown at the left-hand corner, might be done away with by enlarging the bottom plate. The question was one of obtaining certainty of results with an inconvenient apparatus, or having uncertainty with an apparatus that was more convenient. With regard to the lag of the thermometers, it would be seen, on reference to Fig. 6 in the paper, that the total time of experiment was about nine minutes, and he did not consider that a lag of half a second, mentioned by Captain Sankey, would be very serious in such a slowly-changing pressure. Captain Sankey had inquired whether the wire frame gave the mean temperature. That point had given the speaker serious thought, and he would not say that the wire frame did give the mean, although he considered it to give something tolerably near the mean. When the experiments were initiated he had in view a number of schemes for putting thermo-couples at different points for circulating air in the receiver; but all the schemes would have involved great practical and experimental difficulties, and having regard to the nature of the results obtained, he felt justified in assuming that the temperatures were tolerably near the mean; he obtained just the same temperature at the point D as he had at the large opening. The question of temperature was not very serious, since, in the calculations, it was the absolute temperature that was considered, and it was only a matter of 2 deg. variation as compared with 520 deg., or thereabouts. In reply to Captain Sankey's question relative to the measurement of the volume of the chamber by water, any quantity of water adhering to the walls was quite inconsiderable compared with the total volume concerned. The speaker admitted that a correction was needed in regard to errors in area A; that those errors did not affect the discharge was true as applied to equation No. 2, where it would be seen that the discharge did not introduce any factor involving the area. If the discharge was to be obtained from the coefficient of the area, of course Captain Sankey was right in saying that there was an error. Captain Sankey had further stated that in the impact experiments the pressure was falling, and that he (the speaker) had had to get a flying shot at the pressure. He (the speaker) should have mentioned that the air-pump supplying the receiver was kept going during the impact experiments, but was not able to fill the receiver as quickly as the nozzle emptied it; it was, however, sufficient to make the drop of pressure very much slower than that shown in Fig 6, and to dispose of any real difficulty. He had been much interested in the slides shown by Professor Morris, and in the remarks with which they were accompanied, but he did not think they called for special comment. The speaker had been quite unaware of the

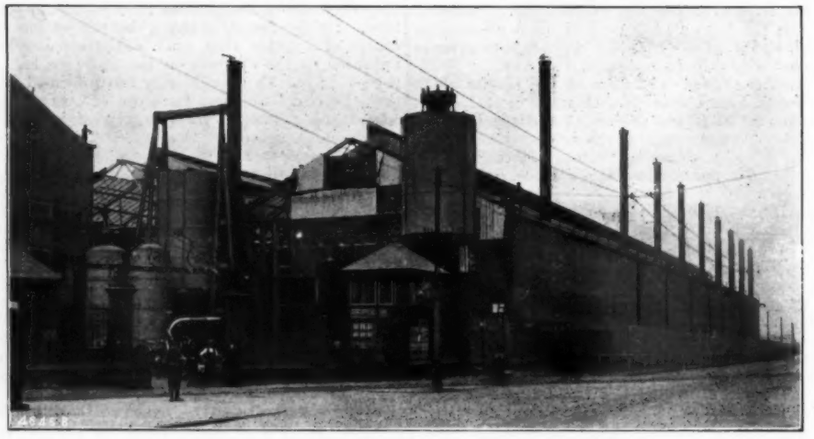


FIG. 2. VIEW SHOWING POWER-STATION AND MAIN BUILDINGS.

method of measuring velocities which Professor Morris advocated, but it seemed one that was capable of very good work. Mr. H. M. Martin had referred to the errors produced in reaction experiments in the case in which the nozzle blank was large; the speaker was certain that those errors did not apply in his own case. He had tried, in some instances, filing away the nozzle blank, but without any change in the result. He, moreover, did not think even a large nozzle-box would have a serious effect, inasmuch as he had tried putting on, in a certain position, a flat plate with a hole in it, so that any air circulating in that direction would have a considerable area to impinge against, but there was no appreciable difference in the result. The last form of cage mentioned by Mr. Martin appeared to the speaker open to the objection that it was hard to tell the position of the nozzle; that was to say, whether the nozzle was not one of very special form, the edge of the bell being really the exit of the nozzle. This militated against certainty of result.

The President then announced that the next meeting of the Institution would be the annual general meeting, and would be held on Friday, February 18, at 6 P.M.

The proceedings then terminated.

ONE OF THE NEW BRITISH PROJECTILE-MAKING FACTORIES

A LARGE part of the feeling of disquietude—not yet entirely at an end—in connection with the production of a sufficient supply of shell—shrapnel and high-explosive—has been due to an inadequate knowledge on the part of laymen as to the extent of the plant necessary for producing shells, and the number of operations and high degree of accuracy involved in their manufacture. As has been time and again pointed out, unskilled labour or partially-skilled labour is utilisable, and is now being employed in increasing measure in most of the operations; this fact suggested that the processes were simple, alike as regards the extent of mechanical appliances and the degree of intelligence necessary on the part of workers. But this is one of those cases where the excellence of the machine in its mechanical accuracy and completeness supersedes experience and mechanical skill on the part of the operative. As we had not contemplated war, and, so far as the Army was concerned, were ill-prepared to meet the drain of warlike operations, it followed that before the production of shells on a sufficiently immense scale could be undertaken the factories had to be organised, or constructed anew, and equipped with the most efficient appliances, so arranged as to ensure the greatest output for the minimum manual effort. When it was realised that the tactics in the field demanded a domination of artillery over infantry or cavalry action, the problem which faced the authorities was the question not only of increasing the emergency supply by almost superhuman effort on the part of the workers available, but also so to augment the producing facilities of the country as to make certain that the immense flow of shells from the muzzles of all the guns in action could be maintained at its maximum volume over a lengthened period.

The argument was used that even little machine-shops should be re-arranged to make shells, or at least to execute one or the other of the many

A NEW BRITISH PROJECTILE-MAKING FACTORY.

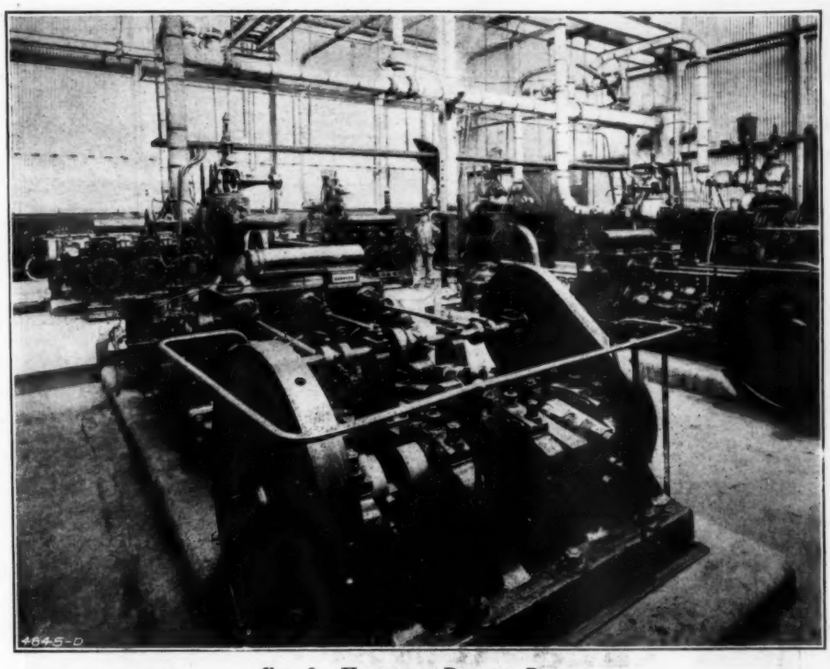


FIG. 3. HYDRAULIC PUMPING PLANT.

operations which constitute the long line of manufacturing processes. It was ultimately realised, however, that with the manual resources of the country taxed to the fullest degree, the transport of shells over great distances, along what we have called the "long line of manufacturing processes," was wasteful in the extreme, and we have known of cases where shells have had to travel miles between the forging and the finished machining. In well-organised works 300 yards suffice. The authorities therefore acted wisely in deciding that while extraordinary measures, however inefficient, might be justified to meet immediate emergency, the preferable course was to arrange for the rapid completion of immense new factories, where the transport would be minimised and the organisation and equipment would be such as to achieve the greatest production with the smallest possible number of men of military age.

We are able this week to publish, on Plates IV., V., VI., VII. and VIII., on the opposite and present pages, and on page 78, a series of illustrations of one of these new machine-shops. Without entering into the details of manufacture, which might be helpful to the enemy, it is possible to convey even to the lay mind such an idea of the energy and enterprise shown in the bringing into action of such a shop as to dispel a large proportion of the misunderstanding and criticism, due to incomplete knowledge, regarding the action of the authorities in meeting the demand for shells.

The shop illustrated, which embraces 10 acres under the glass roof, is one of many now in full operation, turning out thousands of shells per day. Others are being as rapidly brought to the same state of efficient production. Six months prior to the taking of some of the photographs which we reproduce, the site of this immense shop was used as a coal and iron store, and the first operation was the clearing away of between 5000 and 6000 tons of such materials. The ground had to be levelled and the foundations put in, and there was then erected, as our illustrations show, a steel building, which in its completeness and permanence equals anything yet done. Moreover, the admirable details of the design, notably for supporting cranes and for carrying the lines of shafting for the machine-tools, will easily be appreciated by a close examination of the photographs. There are nine bays of an average length of 370 ft., with a total floor space of 196,600 sq. ft. Two of them are arranged as press-shops for the forging from bars into shell cylinders, either of the shrapnel or high-explosive type, ranging in diameter from the smallest to the largest required. The smaller shells are machined in an upper floor over one end of the machine bays, the larger shells in the remaining bays, and railway tracks are laid for the movement of the shells to the bays fitted with the machine-tools for undertaking the finishing operations. Rapidity of output is facilitated by each machine being confined not only to one diameter of shell, but to one separate operation, so that the minimum of time is involved in the setting of the lathe, while the machinist, when initiated into the carrying out of this one operation, becomes very expert, and requires only the slightest supervision.

Figs. 1 and 2, on page 76, are external views of this new shell factory. In the latter there is seen the power-station, with the hydraulic accumulators forming a prominent feature. The principal unit is the installation of pumps for supplying pressure water to the presses for forging the bars into shell-cylinders. A view of the pumps is given in Fig. 3, annexed. There are nine of these, each working up to 1500 lb. pressure per sq. in. They are steam-driven, and the aggregate power developed under ordinary working conditions is about 3000 horse-power. These pumps deliver to two accumulators, 26 in. in diameter by 20 ft. stroke, and the supply of pressure water is controlled by electrical and mechanical devices, which come into action as the accumulator approaches the top of its stroke. For hydraulic pressures of 4480 lb. per sq. in. there are three horizontal pumps, developing 510 horse-power, delivering into a pair of accumulators, 15 in. in diameter by 16 ft. 6 in. stroke, and similarly controlled. Steam is supplied by four water-tube and five Lancashire boilers, all fitted with mechanical stokers. Two of the water-tube boilers are of the Stirling type, and two of the Babcock and Wilcox design, all fitted with chain-grate stokers and induced-draught fans. The boilers are supplied with water from the town supply by vertical feed pumps. Electric and pneumatic power is supplied from a separate central station.

The raw material is brought to the factory in bars of suitable diameter, and stored in racks for ready use. Adjoining these are the parting-machines to cut the bars into the required lengths for the manufacture of single shells. The furnaces for heating these are distributed along the two press-shops, contiguous to the presses, and illustrated in the views in Figs. 5 and 6, on Plate IV. The presses range in power from 160 tons for small shells to others of 2500 tons for the largest. Hydraulic pressure is maintained at two levels—1500 lb. and 4480 lb. per sq. in., according to the size of the presses. These are arranged with two dies, so that the shell is forged at two operations. In the larger of the presses, one of which is illustrated separately with its furnace in Fig. 7, on Plate V., the dies are accommodated on hydraulically-actuated carriages, which move one or other of them under the forging tool. The shell cylinder, after being forged, travels across the several bays, as each of these are arranged to deal with one or two sizes of shell only. Fig. 8, on Plate V., and Fig. 9, on Plate VI., illustrate the bays given up to the machining of large shells, and Fig. 10, on Plate VI., the shop for the work on medium-sized shells. It is not necessary to describe in detail the machines used for rough and finish turning, external and internal. The end is coned, when cold, in a special press, and the preparation of the end for the accommodation of the fuse is done in screwing-machines. Fig. 11, on Plate VII., shows, to the right, the machines used for pressing the copper bands on large shells. Fig. 12, on Plate VII., shows the washing and varnishing department for small shells. Of course, at various stages of the manufacture the shells are carefully gauged, and Figs. 13 and 14, on Plate VII., show the departments where the final assembling and the inspection of the small shells is carried out. Figs. 15 and 16, on Plate VIII., show the inspection department for large shells.

In order to convey an idea, especially to the layman, of the advantage of concentrating shell manufacture in such large establishments, some idea may be given regarding the extent of the work on each shell, and the direction in which labour and time can be saved. In the case of the small shells, the press operations number seven, and the machining operations—done entirely by female labour—17, up to and including the fixing on of the copper band to conform to the rifling of the gun. In the process of filling there are 21 operations in the case of shrapnel shell. This does not include the making and fitting of the fuse and the filling-in of the explosive contents; these operations number forty-five. Thus from beginning to end there are nearly one hundred operations, and each shell may pass through the hands of one hundred workers. But although there is an immense multiplicity of tools suitable for each operation, the shell, from the time it enters the shop as a bar until it leaves ready to be put into the breech of a gun, travels only 400 yards. Here, in itself, is a justification for the aggregation in one building of the plant to complete the whole process of manufacture. The same holds to an even greater extent with the heavier shells.

Similar notes may be given, largely for the benefit of the inexpert, with regard, say, to the medium-sized high-explosive shell. In this case a large part of the work is done by partially-skilled labour. In the press-shop there are eight operations; the shell-body is then transferred to another bay, where it is machined, the operations numbering twenty-two, from the rough turning to the fitting of the copper band, after which the shells are screwed at the nose and a brass bush is fitted. The shells are finally gauged all over and taken to the scales to be weighed; the margin for more or less weight than the standard is exceedingly small. Before the brass bush is finally fitted, the shells are transferred to the washing department, where they are dipped into tanks containing hot caustic soda, to remove grease and dirt from the inside surface. They are next immersed in hot clean water, and subsequently allowed to dry. After this, they are coated internally with copal varnish and then transferred to gas-stoves having a temperature of about 300 deg. Fahr., in order that the varnish may be dried effectively. Finally, the copper band is fitted in position in a press and a brass bush screwed in position. The shell is then ready to be filled with explosive and fitted with a fuse. Similar processes are carried out in connection with even the largest of the high explosive shells.

An essential to rapid work is the provision of a sufficient number of cranes. The enormous amount of work to be dealt with in the factory illustrated may be appreciated from the fact that there are no fewer than twenty-nine electric overhead travelling-

ONE OF THE NEW BRITISH PROJECTILE-MAKING FACTORIES.

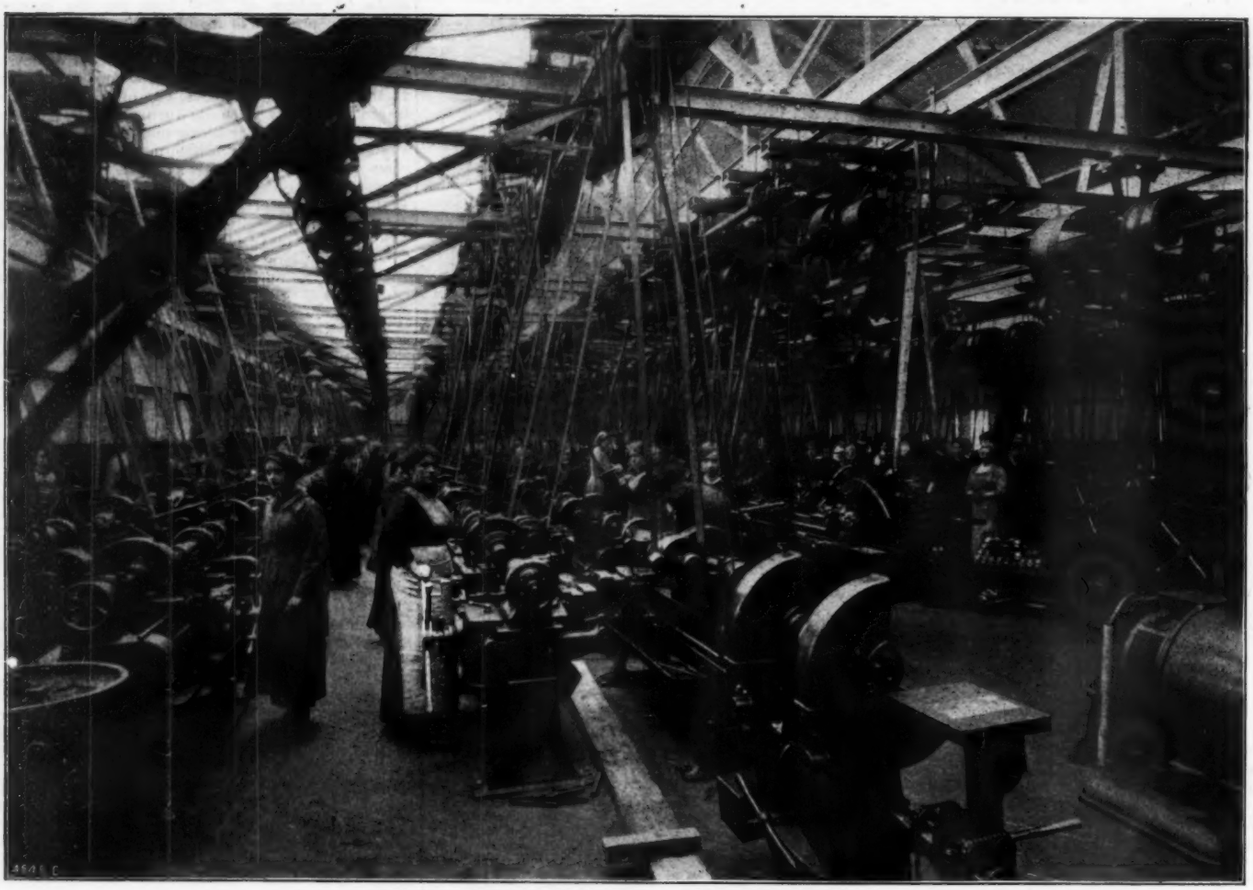


FIG. 4. WOMEN WORKERS MACHINING SMALL SHELLS.

cranes, twenty-eight of these having a lifting capacity of 2 tons, and one of 5 tons, for handling the heavy parts of the presses. All the cranes are of the three-motor type, and have lifting speeds of 25 ft. per minute, cross-traverse of 100 ft. per minute, and longitudinal travel of 275 ft. per minute. Each crane is controlled from a cage suspended under the crane-girders, from which the operator has an uninterrupted view of the shop floor which he is serving. In addition to these cranes, jib-cranes are installed for handling the large billets from the furnaces to the presses.

As Fig. 4, on page 78, shows, the small shells are machined entirely by female workers. In the shop illustrated there are 1800 of them, all imbued with the spirit of serving in emergency in the interests of the nation. Indeed, if in any day the output is a little down, a gentle appeal from the manager is enough to reawaken the workers to the needs of the Army. A girl commencing in the department is able to work a machine after three days' teaching, and becomes quite an efficient machine-worker after seven days, while at the end of two months' experience she attains the highest efficiency. As a rule, one skilled worker can supervise and set the machines for twelve of the female operatives. The work is well done. The accuracy to which the work has to be completed is $\frac{1}{1000}$ part of an inch, and it says much for the care taken that not more than 1 per cent. of the shells made are rejected.

We do not propose to describe the various tools used, as they are all more or less of standard type. Nor is it desirable, in the national interest, to say more of the processes. But to promote the education of the general public, it may be said that in the manufacture of the 3-in. shell the cutting tools of the successive machines travel over 1000 ft., and the average speed is 55 ft. per minute. It is not, therefore, in the actual machine that time is required, but in the movement of the shell from point to point, so that it is in the highest degree important to have the machines for the successive operations as close to each other as space will admit, and not to have them in different factories. It need scarcely be said that the women workers are specially circumstanced so far as dining-rooms and cloak-room facilities are concerned. The 24 hours are divided into three equal portions, so that the female workers are only eight hours at work, but the machines are kept going for the full 24 hours. Under the matrons they work enthusiastically, and earn large wages on the premium-bonus system, while absent time is rarely over 2 per cent. of the total for each week.

This general description of one of the many new shell factories brought into complete operation within six months, or at most eight months, of the clearing of the ground, goes some way to prove that however unprepared we were for a great European war, the authorities have not been idle in making a thoroughly adequate arrangement for ensuring that the fullest possible demands of the Army shall be met, and the requirements will be continuously supplied in full measure. At the same time great help is being given to our Allies in supplies of ammunition. The one need is for the supply not only of unskilled and partially-skilled men and of women, but also of skilled workers to supervise the operations of the others. There has been difficulty in securing an adequacy of experts for the running of these factories; but this is now being met, and as the trade unionists are taking a wider view and more satisfactory attitude with regard to the national needs, the people of the country may rest assured that in the immediate future the supply of shells, if not of all ammunition, for the prosecution of the war to a successful end will be continuously abundant, and also that it will be secured at a highly reasonable expenditure. The views on Plate VIII., showing shells ready for despatch—an ever-recurring view—is a tribute to, as well as evidence of, the energy of the Minister of Munitions.

INDUSTRIAL NOTES.

DEALING in Parliament on Friday last, the 21st inst., with the question of Dilution of Labour, the Prime Minister stated that the Government had given this matter the most careful and anxious consideration. They were convinced, after taking into account all other methods of increasing the available supply of labour for munition work, that the adoption of dilution—*i.e.*, the employment during the war period of semi-skilled and unskilled and female labour on any class of work upon which it can be usefully employed, so as to set free skilled workmen for the work which they alone can perform—offered the only prospect of securing a sufficient supply of munitions to enable the war to be brought to a speedy and successful conclusion. It was quite impossible for foreign supplies to take the place of home production of munitions, since even if these sources of supply could be indefinitely expanded, the immense demands thereby entailed, both on our financial resources and on our shipping, would present insuperable difficulties.

The necessities of the war had been pointed out both to the owners of controlled establishments and to the representatives of the great trade unions, and they had loyally pledged themselves to support the Government in the scheme of labour dilution, the necessity for which had arisen from the national requirements, and not from any demand by employers. Guarantees as to the nature and temporary character of the changes had already been given, and considerable progress had already been made in certain districts to give effect to the policy indicated; but he regretted to say that what had hitherto been accomplished fell lamentably short of the national requirements in the present emergency.

The Government accordingly proposed to take steps to bring about this dilution of labour wherever needed,

in accordance with the necessities of the situation and on the conditions laid down, after agreement with the representatives of the workmen, in the Munitions of War Act as amended, without further delay. They were issuing instructions to controlled establishments to secure this where this had not been done, and they were sending special representatives to the most important districts to assist in giving effect to their policy.

He relied confidently on the support, both of employers and of workmen, in a matter which was vital to the successful prosecution of the war.

With reference to the Prime Minister's announcement, given above, His Majesty's Government have appointed Commissioners to visit the Clyde and Tyne districts for the purpose of applying and carrying into immediate effect the policy of the Government in this matter. The names of the Commissioners appointed for the Clyde district are as follows:—Mr. Lynden Macassey, K.C. (chairman), Sir Thomas Munro, and Mr. Isaac Mitchell.

Mr. Macassey has undertaken a large number of the arbitrations for the Government in industrial disputes both under the Conciliation Act and under the Munitions of War Act. Recently he was associated with Lord Balfour of Burleigh as a Special Commissioner to inquire into differences affecting munition workers in the Clyde district. He has had practical experience in engineering workshops. Sir Thomas Munro is a well-known public man in the Clyde area. He is the County Clerk of Lanarkshire, and holds other public appointments in the county. Mr. Mitchell is Assistant Industrial Commissioner in the Board of Trade, and has assisted the Chief Industrial Commissioner, Sir George Askwith, in conciliation and arbitration in labour disputes. Mr. Mitchell was a working engineer, and subsequently held many positions in the trade-union world, including that of secretary to the General Federation of Trade Unions.

The names of the Commissioners for the Tyne district are as follows:—Sir George Croydon Marks, M.P. (chairman); the Right Hon. G. N. Barnes, M.P.; Mr. David James Shackleton.

Sir George Croydon Marks, the chairman, has had an extensive acquaintance with engineering in all its branches. He was himself an apprentice as an engineer in Woolwich Arsenal, and passed through the workshops and drawing-office, and subsequently filled various responsible positions with engineering firms in London and the provinces. Mr. David Shackleton is an Insurance Commissioner. He was President of the Trades Union Congress in 1908 and 1909; Chairman of the National Labour Party, 1905; and Member of Parliament for the Clitheroe Division, Lancashire, from 1902 to 1910. He has been a member of various Royal Commissions, and was Labour Adviser to the Home Office before he was appointed an Insurance Commissioner. He has had life-long association with Labour questions. The Right Hon. George N. Barnes is Member for the Blackfriars Division of Glasgow. He was general secretary of the Amalgamated Society of Engineers for ten years, and he has acted as a member of various Parliamentary Commissions.

At the request of the Minister of Munitions, Sir Maurice Levy, M.P., has undertaken important duties in the Ministry, particularly in connection with the improvement of time-keeping in munition factories.

Munitions are being made largely on piecework in American shops, says the *American Machinist*, New York. Men with little or no mechanical skill are being employed on this work. The processes, methods, and tools are, as a rule, highly developed, and individual operations greatly simplified. There is a tremendous pressure on everybody to get out a maximum output for each working-day. Many of the men engaged are earning more money each week than they would get in three, or four, or even five weeks. The wise men keep down their living expenses to a point close to the normal, and build up a bank account against the coming "rainy day," or for use later on in some long-dreamed-of business venture. No one can tell how long the present piecework prices will hold, but the end will come some time; then wages in machine-shops will go back to their normal level, and living will have to go back to a scale in keeping with the current wages for each locality. In many an American machine-shop workmen are now earning far more per week than the foreman who is directing them. Some grumbling is heard; perhaps some of it is justified. In fact, it seems very proper to ask if some bonus scheme should not be adopted whereby the foremen will profit in proportion to the added responsibility, increased hours, and additional amount of profit being earned by their departments. But whenever the foreman's position is considered, it should be remembered that this and his wages are reasonably permanent, whilst the large present-day earnings of his men are temporary.

The outbreak of war in August, 1914, says the *Board of Trade Labour Gazette*, caused great temporary dislocation of industry, which was not entirely overcome until November of that year; but by January, 1915, the percentage of unemployment had fallen to a very low level, largely owing to work required directly or indirectly for the Government; and the percentage fell almost uninterruptedly throughout the year, until the lowest figure ever recorded by the department (0.6 per cent.) occurred in November and December.

The total number of workpeople who were reported, in 1915, to the Labour Department as having received war bonuses or increased rates of wages in the industries for which statistics are available was 3,165,000, and the total amount of increase in the wages of these workpeople was over 603,000*l.* per week, an average of about 3s. 10d. per head.

The changes in hours of labour reported as taking effect in 1915 affected 13,657 workpeople. Practically all of these obtained a reduction in hours, the net weekly effect being a decrease of 34,221 hours per week. These figures relate to changes in the hours of labour in a normal week, exclusive of overtime worked.

The general level of wholesale prices during 1915 was higher than in 1914 by about 22½ per cent. In 1914, however, there was a marked discontinuity in the movement of wholesale prices consequent on the outbreak of war, and comparing 1915 with the pre-war months of 1914 (January to July) the increase is 26½ per cent., and compared with the war period of 1914 (August to December) the increase is about 17½ per cent.

The following table shows the percentage increases in retail prices of food, as compared with the prices of July, 1914, at the beginning of each month of 1915:—

	Per Cent.		Per Cent.
January ...	... 18	July ...	... 32½
February	... 22	August ...	... 34
March ...	... 24	September	... 35
April ...	... 24	October ...	... 40
May ...	... 26	November	... 41
June ...	... 32	December	... 44

Dealing with the iron and steel trade in 1915, *The Iron Age* says that at the close of the year the production of iron and steel was at a rate far in excess of previous attainments in the history of the United States. It is believed, adds our contemporary, that the output of steel ingots is closely approaching the 40,000,000-ton rate per annum, which authorities in the trade had estimated some years ago might be reached by 1920. Every available steel plant, rolling-mill, and blast-furnace was in active operation, with sufficient orders booked to ensure running to full capacity far into the summer, and with consumers endeavouring to place contracts for even more distant delivery. The trade has had previous experiences of great activity and insatiable demand, but never before has been seen anything approaching the conditions existing at the close of 1915.

The fifteenth Financial and Economic Annual of Japan, recently issued by the Department of Finance, Tokyo, gives the following interesting figures for the year ended on June 30, 1913:—The mine employees in metalliferous mines numbered 79,479, those in collieries numbered 172,446, and those in non-metalliferous mines numbered 10,238, or a total of 262,163 operatives, who worked a total number of 67,479,882 days. Of the other classes of operatives, by far the greater number are employed in textile factories, the figures for 1913 being: 71,144 males, 468,929 females, total, 540,073; then follow the machine and tool factories, including shipbuilding and metallurgical works, with 88,245 males, 4994 females, total, 93,239; chemical works, employing 54,930 males, 25,240 females, total, 80,170; food and drink factories, employing 35,856 males, 7274 females, total, 43,130; miscellaneous factories, including printing and publishing, wood and bamboo work, employing 47,634 males, 25,574 females, total, 73,208; and special industries, employing 77,787 males, 8645 females, total, 86,432. The total for all trades is 375,596 males, 540,656 females, total, 916,252. The following daily wages for 1913 are gathered from a detailed table contained in the Annual, taking the yen at 2s.:—Carpenter, 1s. 9d.; plasterer, 1s. 11d.; stone-cutter, 2s.; bricklayer, 2s. 2d.; shipwright, 1s. 11d.; founder, 1s. 5d.; blacksmith, 1s. 5d.; compositor, 1s. 2d. Taking the average wages reported in 1900 at 100, the following are the index numbers of several wages paid in 1913:—Carpenter, 163; plasterer, 172.2; stone-cutter, 165.6; bricklayer, 173; shipwright, 166.1; founder, 155.3; blacksmith, 152.1; compositor, 165.7.

BRIDGES FOR THE FEDERATED MALAY STATES RAILWAYS.—It is understood, says *The London and China Telegraph*, that the contract for fourteen bridges, ranging from 20 m. to 60 m. (65 ft. to 196 ft.) span for the Federated Malay States Railways has recently been awarded to the Cleveland Building and Engineering Company, Limited, Darlington.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Canada: According to telegraphic information received on January 14, at the office of the High Commissioner in London for Canada, from the Minister of the Interior at Ottawa, the British Columbia Manufacturers' Association is about to form a joint stock company to carry on shipbuilding. It is proposed to construct fifteen ships immediately at shipyards in Vancouver, Victoria and Prince Rupert. H.M. Trade Commissioner in Canada also reports that tenders will be received by the Chairman, Board of Control, City Hall, Toronto, up to noon on February 1, for the supply and delivery of street cars; bodies, trucks, motor equipment, air-brake equipment and fare-boxes for street cars; also copper cables for street-car work.

Australia: The *New South Wales Government Gazette* notifies that tenders are invited by the New South Wales Government Railways and Tramways Department for the supply and erection of a 2500-kw. turbo-alternator for the Zarra-street Power House, Newcastle, N.S.W. (Specification No. 470.) Copies of the specification, conditions and form of tender may be obtained from the office of the Electrical Engineer, New South Wales Government Railways and Tramways, 61, Hunter-street, Sydney, on payment of 1*l.* Tenders, made out on the proper form, will be received by the Chief Commissioner for Railways and Tramways, Philip-street, Sydney, N.S.W., up to noon on May 3. The *Gazette* also publishes an official notice authorising the construction of two sections of the Wyalong-Lake Cudgellico Railway, representing a total distance of about 28 miles.

India: According to *Capital*, Calcutta, one of the principal functions of the Punjab Department of Agriculture is the introduction to farmers of modern agricultural implements. In the year ended June 30 last, the department gave demonstrations of the use of these implements at eighteen fairs. These demonstrations sometimes resulted in the immediate sale of implements, and, in any event, did great good by exciting general interest in them. The lending of implements to selected cultivators has become a practice with this department, and some 300 implements of various kinds are now out on loan. As a result, may of the instruments recommended by the department have increased in popularity. The average number of implements sold by the department during each of the five years ended June 30, 1910-14, was 346; but in the year ended June 30, 1915, the number sold was 975. A shortage of these implements, particularly of ploughs, is anticipated. Experiments in well-irrigation, it is stated, have been handicapped by the difficulty in obtaining the necessary plant and material owing to the war.

Argentina: The *Boletin Oficial*, Buenos Aires, publishes a Decree authorising the Argentine State Railways Administration to construct a section of the projected Milagro-San Luis line—viz., between the station of Milagro, on the Northern Argentine Railway, and the town of Quines, a distance of 50 km. (about 31 miles).

THE ROYAL SOCIETY OF ARTS ALBERT MEDAL.—In the absence of the President of the Society, H.R.H. the Duke of Connaught and Strathearn, K.G., Dr. Dugald Clerk, F.R.S., Chairman of the Council, last Monday afternoon, at a meeting of the Council, presented the Society's Albert Medal to Professor Sir Joseph John Thomson, O.M., D.Sc., LL.D., F.R.S., "for his researches in chemistry and physics, and their application to the advancement of arts, manufactures, and commerce." The Society's Albert Medal was founded in 1863 as a memorial of H.R.H. the Prince Consort, and is awarded annually "for distinguished merit in promoting arts, manufactures, and commerce."

DONCASTER.—In consequence of the growing development of the coal-mining industry in the neighbourhood of Doncaster, the Doncaster Rural District Council is proceeding with sundry town-planning schemes to meet the requirements of a rapidly-growing population. One of the difficulties in the way is the low-lying character of the land available, hundreds of acres in the Valley of the Don having been flooded during the past month. Little land north and east of Doncaster is more than 20 ft. above sea-level, and the fall in the Don and large main drains is very slight, so that the problem of adequate drainage is an exceptionally difficult one. In the Askern area, which has been already planned for additional houses, 2436 acres out of 5170 acres are less than 20 ft. above sea-level, and regulations have accordingly been drafted, and are receiving the consideration of the Local Government Board, with a view to preventing the use of this low-lying land for the erection of houses. It may, however, be utilised for industrial buildings. Houses at Askern and also at Owston, in the Carcroft area, are being laid out upon a definite plan, with the co-operation of colliery lessees, and they are being erected as they are required. It has recently been decided that town-planning should be continued by the Rural District Council staff, the urban authority contributing part of the cost. Sir Arthur Markham, M.P., has introduced a building scheme at Owston; but here, as at Askern, the drainage difficulty is a serious one.

ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION OF THE LANCASHIRE AND YORKSHIRE RAILWAY.

(*Concluded from page 58.*)

ROLLING-STOCK.

THE electric trains for this service have been built at the company's carriage and wagon works at Newton Heath, and consist of either two, three, four, or five bogie-cars, according to the requirements of traffic, but the standard train will have five cars, the front, centre and rear vehicles being third-class motor-cars, and the intermediate vehicles first and third-class trailer cars. A feature of the design is that the driving compartment for the accommodation of the driver is at each end of all cars, which enables the trains to be made up to any accommodation required with the minimum of shunting operations, time being of the utmost importance on an electric service.

The illustrations which we give on Plates IX., X., and XI., published with the present issue, together with those given on the present and opposite pages and on page 84, will give a good idea of this rolling-stock. On Plate IX., in Figs. 43 to 49, are shown the details of a motor-car underframe, while Figs. 50 to 56, on Plate X., give various views of the motorman's and the high-tension compartments, and a general plan of the car will be found in Fig. 66, on page 81. On Plate XI., in Fig. 57, is given a view of the underside of a motor-car, showing the arrangement of brake-cylinders and resistances, while Fig. 58 shows the ends of a pair of coupled cars, and illustrates the arrangement of couplers, vestibules, and cable-couplers. Figs. 59 and 60, on the same plate, are respectively exterior and interior views of a third-class motor-car, while the interior of a first-class trailer-car is shown in Fig. 61. On page 84 the illustrations (Figs. 67 and 68) refer to a third-class trailer-car, being respectively a part longitudinal section and part plan, which show clearly the arrangement of the seating accommodation, the position of emergency windows, and the arrangement of the vestibules and entrance-doors. Figs. 69 to 72, on the same page, show the constructive details of a bogie for a trailer-car.

Possibly the most interesting feature, from a public point of view, is that timber has been entirely superseded by metal in the construction of these cars, the vehicles being therefore entirely fireproof. The framework is of steel, the panelling of the sides and roof is made up of aluminium sheets, the interior work being finished with mouldings of drawn steel and aluminium sections. The net rod brackets, air-extractors and electrical fittings, together with all inside furniture of the cars, are in polished aluminium. The doors, which are of steel, are shown in Fig. 58, on Plate XI., and Figs. 67 and 68, on page 84. The all-metal car has largely been introduced in America, and to some extent in this country, but hitherto the term has been somewhat of a misnomer, as timber has been largely used for windows, seats, packings and other fittings; it is therefore a point of some importance that the new cars which will run on the Manchester and Bury electric line will, no doubt, be the first passenger cars in either country, and probably in the world, in which metal has superseded wood entirely in the construction of railway vehicles.

The following are particulars of the motor and trailer-cars:—

Total length of five-car train ...	326 ft. 3 in. over all
Seating accommodation of five-car train	72 first-class and 317 third-class; total, 389 passengers
Length over body	63 ft. 7 in.
Length over couplers	65 ,, 3 ,,
Height from rail to top of roof ...	12 ,, 4½ ,,
Centre to centre of bogies	45 ,, 0 ,,
Wheel-base of motor-car bogies ...	9 ,, 0 ,,
Wheel-base of trailer-car bogies ...	10 ,, 0 ,,
Total weight of five-car train	220 tons
Weight of motor-car	54 ,,
Weight of trailer-car	29 ,,

The vehicles have been designed with a slight taper on the sides of the bodies, and with elliptical roofs, the cars having large side-lights and fan-lights. The flooring has been built up of "Keystone" or "Chanarch" galvanised sheets, which are riveted to the steel underframe, and on these sheets is laid "Flexolith" or "Decolith" composition. The cars are entered at the extreme ends of each vehicle, through vestibules, and gangways are provided throughout the trains so that passengers can pass from one car to another to secure a seat. A feature of note is that the usual step-board used on most British trains is dispensed with, and passengers will be able to enter the vehicles direct from the station platform without making the usual intermediate step, which will be a decided advantage in quickening the ingress and egress of passengers at the stations. Each car is divided into two main passenger compartments, with a centre aisle, fixed and reversible seats being arranged alternately on either side, as shown in Figs. 67 and 68, on page 84. The first-class seats are upholstered in tapestry, and the third-class in rattan; the former cars have the floors carpeted (see Fig. 61, on Plate XI).

Other interior fittings of importance are the arrangement of electric lighting and heating, the former of which gives an excellent distribution of light, and the latter, arranged in ducts along each side of the car at the floor-level, ensures comfort in the coldest weather. Electric fans are also fitted, and by means of a two-way switch they can supply fresh air from the outside or extract foul air from the inside of the car. Sanitary strap-hangers, for rush periods, are provided in the third-class cars, these hangers being secured to the roof by aluminium brackets.

The painting of the outside of the cars is in the standard colours of the railway company, whilst the interior is finished in self-colours, the lower part in dark-brown, from the waist-panels to the cornice in a restful shade of green, and the roof being of white. Large panorama photographs of places of interest completes the artistic effect of the inside decoration of the car.

ELECTRICAL EQUIPMENT FOR CARS.

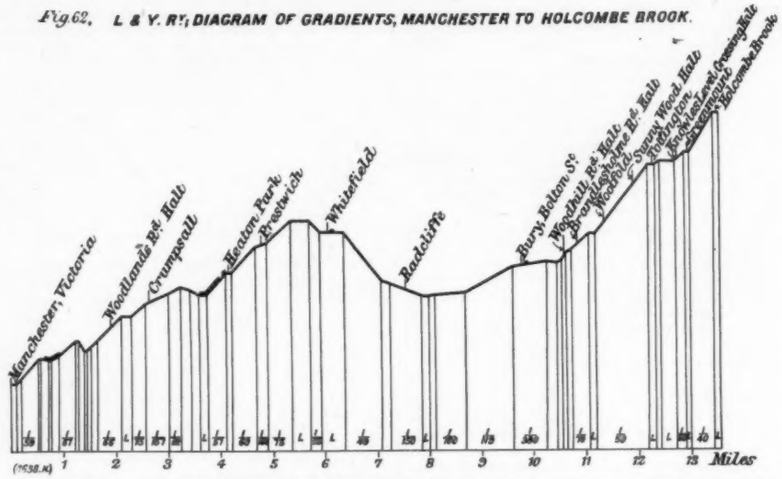
The control equipment on the cars is of the multiple-unit system, and is arranged to be operated on the automatic principle—that is, instead of the motor-man notching up in the usual way by hand, he puts his controller into the "full series" or "full parallel" position, the various intermediate steps being performed automatically. It can also be operated by hand by simply moving the reversing lever to a certain position. The control equipment on each car is capable of controlling the four 200-horse-power traction motors, with a line voltage of 1200, to give "series parallel" and "parallel" combinations of the motors. The whole of the equipment is operated by 100-volts direct current, which is transformed from the line voltage (1200) by means of a rotary transformer mounted under the car. All the 1200-volt equipment is housed in a special high-tension chamber, the door of which is interlocked, so that the isolating switch connecting the control leads from the shoes must be opened before entrance can be effected. The arrangement of the motorman's compartment and of the high-tension compartment is shown in Figs. 50 to 56, on Plate X.

All the contactors, the reverser, and the motor cut-out, are mounted on the inner wall of the high-tension compartment, opposite the window, and above these are mounted the isolating switch, main fuse, main-circuit breaker, and in an auxiliary high-tension chamber is the starting-gear for the rotary transformer, with its isolating switch. The high-tension wiring is carried in flexible steel tubing.

The motorman's compartment contains a brake-valve, fitted with an emergency handle which, on release, applies the brake instantly, and also trips the control circuit, thereby opening all the contactors, a master-controller, and a hand-brake, together with the switches for lighting and the necessary switches and fuses for the control and brake. Also the compartment contains the automatic controller and regulator for the vacuum-pump. The arrangement shown is the same at each end of the motor-car, with the exception of the brake-pump controller and regulator. The reverser handle on the master-controller has four positions, reading from right to left: "Reverse," "Off," "Ahead automatic control," and "Ahead manual control."

It will be noticed that one of the positions is "Ahead manual control." This is used in cases of emergency due to failure of the "Automatic control." Normally, this is a stop which is sealed, and which prevents the reverser handle being placed in the "Manual" position. There are four "series" points on the controller, three "intermediate" and three "parallel," with an additional two positions, by which the field of the motors is shunted when higher speed is required for express traffic. All the cables, with the exception of the trolley-cable, are carried in sheet-steel troughs; the trough for the trolley-cable is made of Jarrah. Each equipment consists of fourteen contactors, which are of the "hammer" type, with a rolling action, and are fitted with special soapstone dished arc-horns for receiving the arcs. The control equipment has been supplied by Messrs. Dick, Kerr and Co., Preston.

Fig. 62. L & Y. R^y. DIAGRAM OF GRADIENTS, MANCHESTER TO HOLCOMBE BROOK.



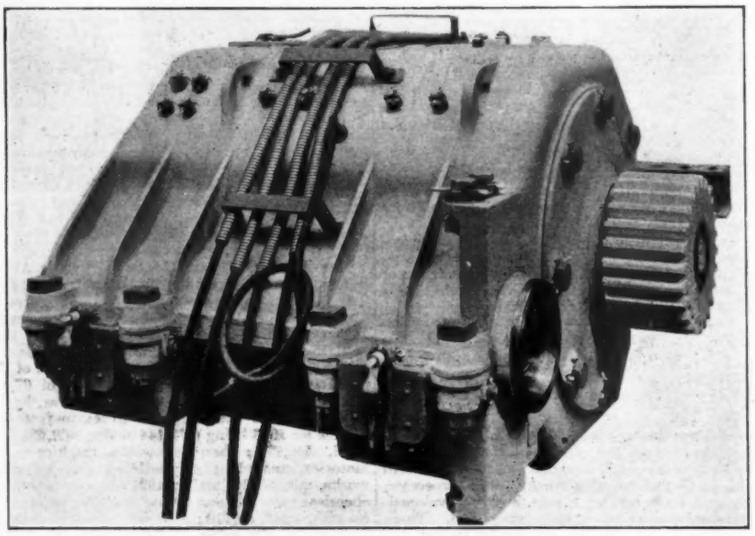
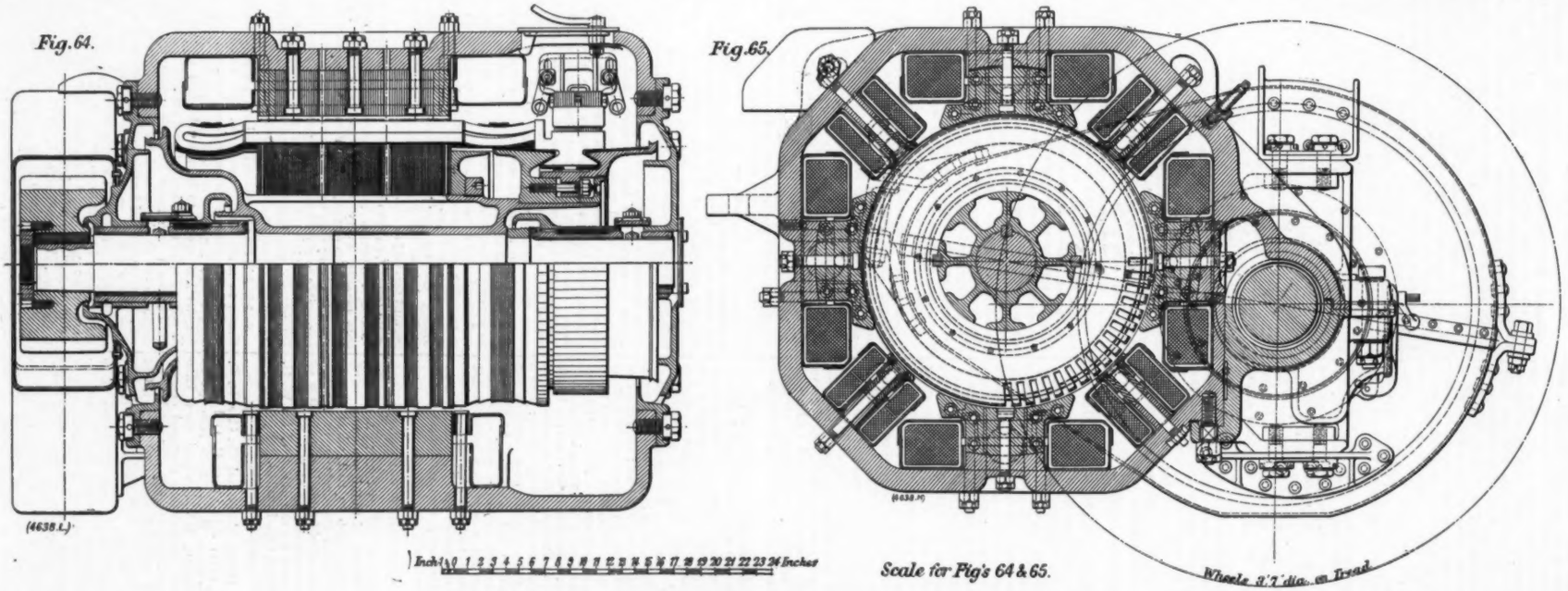


FIG. 63. 200-HORSE-POWER MOTOR.

Motor-Bogies (see Fig. 34, on page 57 *ante*).—The motor-bogies complete, which have been designed and built at the railway company's locomotive works at Horwich, carry two 200-horse-power motors mounted and geared to the axle through spur-gearing, the ratio being 25/59, or 2.36 to 1. On each side of the bogie is mounted a shoe-beam carrying the collecting shoe. Each motor-car is provided with two of these bogies, making a total of four motors, or 800 horse-power per car, the gradients being somewhat severe, as will be gathered from Fig. 62, above. The wheel-base of the bogies is 9 ft., and the diameter of the wheels 3 ft. 7 in., the wheels being of



FIGS. 64 AND 65. LONGITUDINAL AND CROSS-SECTIONS OF 200-HORSE-POWER MOTOR.

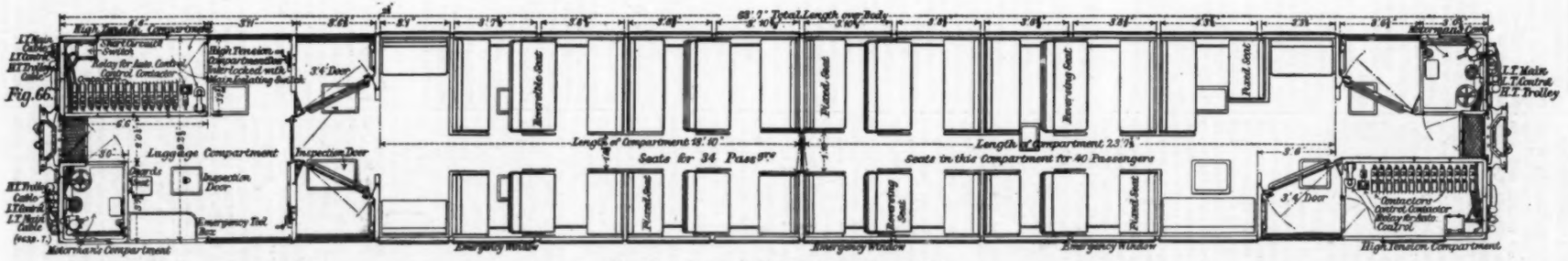


FIG. 66. PLAN OF THIRD-CLASS MOTOR-CAR.

standard locomotive pattern. There are two brake-shoes per wheel.

Motors.—The motors, shown in Figs. 63, 64, and 65, on the present and opposite pages, are designed for 1200 volts, series wound with commutating poles, and are totally enclosed. The field frame is in one piece, of the "box" type, the main poles being arranged vertically and horizontally, this arrangement having been found to give the best space efficiency in the limited room available. The ventilation of the motors has been carefully considered and provided for. The armature laminations are carried on a hollow spider which also carries the commutator. There is a free passage of air through the spider and through the ventilating gaps in the armature which are continued through the main poles to the outside atmosphere. The armature coils are all insulated with solid mica insulation, and the field coils are enclosed in brass cases, to keep them from contact of oil. Ring lubrication is used for the armature shaft, the oil-wells being of ample proportions; oil lubrication with pads is adopted for the suspension bearings. The brush gear is carried on a solid-steel yoke bolted to the frame, which is insulated with solid mica, and forms a very rigid construction. Special attention has been given to the machining of the various parts, so as to ensure interchangeability.

Brake.—The brake is the standard automatic vacuum-brake, so that, if necessary, ordinary steam trailer-cars can be coupled to the electric rolling-stock, the brake still being effective. The vacuum is produced by means of a twin-cylinder exhauster, driven through gearing by a Mather and Platt 5-horse-power 100-volt motor. This arrangement is shown in Fig. 57, on Plate XI., which also shows the brake cylinders and the resistances.

In arranging the apparatus underneath the car, every consideration has been given to accessibility for maintenance purposes. The heating is operated off the 1200-volt circuit, and the lighting, pump motor, and control off the 100-volt circuit. The trolley-cables, of which there are two—one on each side of the car—are continuous throughout the trains, connections being made through couplers, as shown in Fig. 58, Plate XI. This figure also shows the multiple couplers for the control and the coupler for the bell and brake exhauster control.

JAPANESE COAL.—The output of Kiushiu coal in Japan in 1914 was 15,750,000 tons; of Hondo coal, 2,110,000 tons; and of Hokkaido coal, 2,742,000 tons, making an aggregate production for the year of 20,602,000 tons. Coal was also imported during the year to the extent of 1,047,000 tons. The stocks brought into 1914 from 1913 were 542,000 tons, and 1,942,000 tons were carried forward to 1915. Of the coal available in Japan in 1914, 16,854,000 tons were absorbed by home consumption, and 4,195,000 were exported.

GERMAN COAL AND IRON INDUSTRIES.

THE quantities of coal disposed of by the Rhenish-Westphalian Coal Syndicate in November, 1915, show a falling-off, both compared with the previous month and with November, 1914, the figures being, respectively, 4,412,399, 4,841,848 and 4,600,119 tons, representing, respectively, 62.08, 63.34 and 65.29 per cent. of the allotment. The production during November amounted to 6,231,775 tons, against 6,467,468 tons in October, and 5,753,293 tons in November, 1914. In August, 1914, the sale only amounted to 33.35 per cent. of the allotment; it then gradually, though not altogether steadily, increased to 70.16 per cent. in June, 1915, but since then it has again diminished. As regards coke there is also a decrease, the quantity despatched during November only amounting to 1,431,586 tons, against 1,564,730 tons in October, and 1,630,525 tons in September; the latter was the highest figure since the war broke out, while the lowest was that for August, 1914, which was only 553,912 tons. The Coal Syndicate attributes the lower figures for November exclusively to the shortness of rolling-stock, which was further emphasised during that month. The sale of briquettes in November amounted to 66.66 per cent. of the allotment, against 70.84 per cent. in October, and 87.96 per cent. in November, 1914. The State coal mines in the Saar district have commenced sales for 1916, but, in accordance with the arrangements with the Coal Syndicate, only for the first two months of the year and at the old prices. In special cases sales beyond the two months have been concluded. The coal mines of the Ruhr district seem to be doing satisfactorily, judging from the profits to be distributed for the last quarter of 1915, as far as they are already known. The full accounts are not available, but the proposed dividends show that the improvement manifested during the third quarter has been continued during the last. Thus the dividend for the Constantin concern will probably be raised from 500 to 800 marks; that of the König Ludwig Company from 250 to 400 marks; and that of the Fröhliche Morgensonne from 75 to 100 marks, and so on. The Blankenburg in Hammerthal concern, which for years has been unable to pay any dividend, will pay a dividend of 50 marks per share for the last quarter of 1915. The larger mines, which belong to, and are worked as, limited companies, and not as the old-fashioned Gederkschaft, are likely to pay dividends increased by several marks per cent., and the Bochum Mining Company will again be able to pay a dividend. The prospects for the current year are also considered to be satisfactory.

The lignite and lignite-briquette concerns in Central Germany are desirous of bringing about an understanding as to increased prices on account of the higher cost of production, and the Government is believed to have been approached on this subject. As in the case of the Coal Syndicate, the Government is able, by fixing maximum prices, to exercise a certain amount of control of the movement of prices, so that the lignite companies are not likely to make an increase without first conferring with the Government, which has hitherto been against an increase of quotations. As the prices of the Coal Syndicate only hold for January and February, the whole question of prices will probably be taken up shortly for both coal and lignite.

As regards the Siegerland iron-ore and iron industry, the business for the first portion of the new year is reported to be satisfactory. For most commodities there is a lively demand at prices which are certainly not below those of the preceding months; this is to some extent due to orders from neutral countries. The prices obtained for export are fairly satisfactory and in some instances higher than the home prices, especially for all kinds of plates, for which neutral countries are becoming more and more dependent upon Germany. As regards iron ore, the limited quantities available have been promptly taken up, so that only quite small lots remain to be disposed of. Siegerland raw ore costs 163 marks per wagon of 10 tons, and roasted iron ore, 245 marks. For ores from the Lahn and Dill districts a lively demand continues, and in some cases the whole production for 1916 has been sold—Nassau red ore at 20 to 21 marks, and brown ore at 16.50 to 17.50 marks per ton. Negotiations are pending for the sale of several iron-ore mines of the district to large iron works. The Siegerland blast-furnace owners have several times applied for prices to be raised, but the Pig-Iron Union has not entertained these appeals; prices may, however, be influenced by the coke prices to be fixed by the Coal Syndicate for March and forward. A rise in the coke prices is anticipated in several quarters, and the Pig-Iron Union will then probably have to raise its quotations. A ready sale for 1916 is expected. In the Siegerland district, the bar-iron industry is based largely upon quality materials, and prices naturally vary considerably according to the nature of the order. For immediate delivery, prices as high as 150 marks are obtained, but for the current quarter a number of orders have been closed at 145 marks. The market for Siegerland plates is firm, and has been further steadied by the formation of the Plate Union. Heavy plates have recovered some 5 marks, and ordinary Thomas plates are now quoted at 155 marks. The demand is lively, and even before the beginning of the year some 75 per cent. of the first quarter's production was disposed of. Thin plates are also in demand, and the sales made for the current quarter show no falling off; prices range between 185 and 190 marks. For export higher prices are paid, especially for early delivery, which the works are usually unable to effect, as they are taxed to their full capacity. The rolling mills have at last succeeded in bringing about the price convention, which they have for years worked for, and prices have been adjusted in accordance with the higher prices for iron ore and other increased costs. The works are well employed.

The wire market is satisfactory. Rolled wire, on account of the limited production, is in very good demand; the convention price is 140 marks, and, in the meantime, the cutting of prices seems to have come to an end; for prompt delivery an advance is paid. In the different branches of the wire-drawing industry the works are fully employed. In the rolled-wire industry a movement is on foot for the purpose of establishing an export rolled-wire union on similar lines to the bar-iron union, and most of the works have now arrived at an agreement about the principal points. As the rolled-wire works belong partly to the same owners as the bar-iron works, the idea is natural enough, but with rolled wire the only question appears to be one of price regulation, whereas with the bar-iron works there is also a question of allotment.

The production of pig-iron and steel during November showed a decrease of 57,221 tons and 22,470 tons, respectively, as compared with October, the outputs for November being, respectively, 1,019,122 tons and 1,192,817 tons. The production was, however, practically double that for the first month after the declaration of war. The production of steel has steadily, though slowly, advanced since July, whereas that of pig-iron has been almost stationary.

Compared with the production for January, 1914, that of pig-iron has decreased by about one-third, whereas the decrease for steel is about one-fourth. The fact that the production of steel so considerably exceeds that of pig-iron has caused some comment, but this is attributed to the fact that certain quantities of pig-iron have been held over from previous months.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, January 12.

PRICE advances have been made this week on bars, plates, shapes, pipe, boiler-tubes, spikes, sheets, and tin-plate, averaging from 1 dol. to 3 dols. a ton. Average steel prices prior to December were 1.25 dols.; in that month, 1.40 dols.; present business, 1.85 dols. minimum. New steel plants and open-hearth furnaces under construction will add 1,250,000 tons a year, while pig-iron capacity is now practically at its maximum—39,000,000 tons. Ten blast-furnaces are under construction, but only two of them will be completed this year. New incoming plant represents the last word in iron and steel-making; this means that when the rush subsides much old plant will be practically valueless. Conditions are restricting normal production, thus enhancing prices; Bessemer is 21 dols. at furnace, and is largely cornered by two large interests, which forced French buyers to offer 22 dols. for 5000 tons; it will probably reach 25 dols. before any reaction can set in; other lines will act and react similarly, but the date of reaction is unforeseen. Faint promises of a release on the present embargo are made; freight congestion is most serious, but little material can be promised before mid-summer.

An immense amount of mill capital is doomed to practical extinction unless post-war demands should assume and maintain greater magnitude than is at present contemplated. As an evidence of expanding capacity which may send more or less existing capacity to the scrap-pile, reference can be made to the volume of capital being invested at Bethlehem, Pittsburg, Chicago, and several other points. Among Bethlehem improvements may be mentioned a Willing pig-casting machine; rebuilding of blast-furnace B to a 500-ton-a-day capacity, with 52 by 100 stoves; two new mills, 16 in. and 12 in. and 12 in. and 8 in.; 14 open-hearth furnaces; a 2000-ton forging-press; a three-high 18-in. mill; a two-high 12-in. mill, with ten stands for rolls; a 100-ton ladle crane; a 10-ton electric furnace; four additional 3000-kw. alternating generators; an immense scrap breaking plant; and a 1500-ton straightening press—these do not cover all the recent improvements made and making. At Chicago eight additional open-hearth furnaces, with an annual capacity of 1,000,000 tons, is a part of a 5,000,000-dol. outlay at that point, which includes blooming mills and structural mills. War conditions are necessitating a re-organisation of the steel industry which will have serious results in some directions.

SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED.—Sir Philip Watts, K.C.B., who was naval architect to this firm from 1885 to 1901, when he was appointed Director of Naval Construction at the Admiralty, a position which he held down to 1912, when he became adviser in naval construction at the Admiralty, has been elected to a seat on the Board of Sir W. G. Armstrong, Whitworth and Co., Limited.

PERSONAL.—Messrs. Henry Faija and Co. (Mr. D. B. Butler, Assoc. M. Inst. C.E., F.C.S.), of 41, Old Queen-street, Westminster, London, S.W., have removed to 6, Earl-street, Westminster, S.W., where they have secured larger and more commodious Portland cement testing works and chemical laboratories.—Messrs. Boving and Co., Limited, have removed from Union-court, Old Broad-street, E.C., to Imperial Buildings, 56, Kingsway, London, W.C.—Messrs. Wailes, Dove and Co., Limited, Newcastle, have changed their name to Wailes Dove Bitumastic, Limited.—Messrs. Thomas and Bishop, inform us that, owing to the greatly increased sales of "Permac" jointing material and "Cling Surface" belt preservative, they have removed their staff to No. 37, Tabernacle-street, in order to have their general offices, stores, and works under one roof. Their accounts department, however, will continue at Balfour House, 129/125, Finsbury Pavement, E.C.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Wednesday afternoon the market steadied a little, and the recovery effected reduced the decline in price over the day's dealings from 9d. to 4d. per ton. The transactions amounted to 1000 tons, and at the close sellers were quoted 79s. 10d. per ton cash and 80s. 4d. one month. On Thursday morning a very considerable advance was recorded, Cleveland warrants being quoted by sellers at 80s. 6d. per ton cash and 81s. one month, dealings taking place up to 80s. 4½d. cash and 80s. 10½d. one month; at these figures 3000 tons changing hands. A record was reached, the prices being the highest touched during the past forty-two years, nothing like it having occurred since 87s. 6d. per ton was realised for the ruling quality in 1874. A further advance was recorded at the afternoon session, when one month's iron touched 81s. 1½d. per ton, with sellers over at this figure at the close, when sellers' cash price was 80s. 7½d., with 80s. 9d. eight days. Business to the extent of 3500 tons was engaged in. This level was well maintained on Friday forenoon, and although no dealings took place in cash iron, which remained unchanged at 80s. 7½d., 1000 tons were dealt in at 81s. 1½d. per ton one month and 80s. 9d. seven days. While business was quiet in the afternoon, the tone was firm, the only transaction being one cash warrant, which realised 80s. 7½d. At the close sellers' quotations stood at 80s. 9d. cash and 81s. 3d. one month. Strength continued to develop on Monday morning, when cash warrants were done up to 81s. per ton, closing with sellers at 81s. 4½d., while one month's iron advanced to 81s. 10d., with sellers over at this figure. Transactions amounting to 4000 tons were reported. The afternoon showed a further improvement, Cleveland warrants reaching 81s. 9d. cash and 82s. 3d. one month, 82s. being paid for one month's iron, which alone was dealt in. Complete idleness prevailed in the pig-iron warrant market yesterday (Tuesday) forenoon, but the tone was firm, sellers quoting 3d. per ton in excess of the previous day's values. In the afternoon one lot of Cleveland iron was dealt in, realising 82s. 3d. one month. Cash prices were a trifle easier, closing at 81s. 10d. sellers. Little change took place this (Wednesday) morning, when 81s. 6d. cash and 82s. 2d. twenty-nine days were realised for a small turnover of 1000 tons. Closing sellers' prices were quoted at 81s. 9d. cash and 82s. 3d. one month.

Sulphate of Ammonia.—The demand for sulphate of ammonia keeps firm, but the supply in no way keeps pace with the demand. Prices are still on the same level as last week, and for prompt delivery, Glasgow, 17*l.* 17s. 6d. to 18*l.* is quoted, and at Leith 18*l.* 5s. to 18*l.* 7s. 6d. per ton.

Scotch Steel Trade.—While the output in the various steel making establishments continues unabated, the high rate of ocean freights and the uncertainty and irregularity of delivery of the necessary inward ore are making it very difficult for the Ministry of Munitions to arrive at any satisfactory conclusion as to the levelling of prices. Naturally, things are in a rather uncertain condition, and some makers have already withdrawn prices pending the settlement of the negotiations. The pressure for delivery of all classes of steel, particularly for shell-bars, shows no signs of decreasing, for practically Government, directly or indirectly, is absorbing the whole of the available output, and its demands are insatiable. These demands, the high freights, and difficulties of transit are more and more restricting the ordinary mercantile business, especially since the calls from the French, Russian, and Italian Governments have become so insistent. These show, too, how the circle widens out; indeed, it would almost seem as if the country had been turned into a vast arsenal. With the increase in on-costs there is no wonder that all classes of finished material have mounted up so considerably, and both consumers and makers are much exercised as to what to do to remedy matters. Ship and boiler-plates are greatly in demand, there being in many works sufficient orders to keep the mills running for months ahead. The quotations mentioned last week still hold good, ship-plates costing 12*l.* 10s. per ton; boiler-plates, 13*l.* 10s.; and angles, 13*l.* to 13*l.* 10s., less 2½ per cent. discount for prompt delivery.

Malleable-Iron Trade.—There is no decrease in the volume of business being put through by the malleable-iron makers, every department being full up with work and with orders. While the constant increase in price is giving rise to some considerable anxiety, it is impossible to say what may happen even yet. The best grades of "Crown" bars are still quoted 13*l.* 5s. to 13*l.* 10s. per ton, less 5 per cent. discount, although the commoner sorts may be had for 13*l.*

Scotch Pig-Iron Trade.—The local pig-iron trade continues to make steady progress, and within the past week further advances in price have been recorded, 2s. to 5s. per ton for some of the best grades, while No. 3 foundry iron seems to have established another record. Excellent sales are reported, and makers of hematite are finding ready purchasers for their constantly increasing output, even at the sensational price of about 135s. per ton. The position of foundry iron has increased considerably, being now in much better demand, both for local and foreign account. Despite the high prices ruling, makers show little disposition to book further orders at the present rates, a fact significant in itself. During the week seventy-one blast-furnaces have been in operation in Scotland, this being three more than in the preceding week, and two less than at the corresponding period last year. Makers' (No. 1) iron is now quoted as follows:—Clyde, 107s. per ton; Gartsherrie, 107s. 6d.; Calder, Summerlee, and Langloan, 106s. (all shipped at Glasgow);

Eglington, 101s., Glengarnock, 106s. (both at Ardrossan); Dalmellington 103s. (at Ayr); Shotts 106s. (at Leith).

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Steam coal, cobbles, and nuts are in large demand, while works are securing practically full supplies. Shipments have not been so large at the Humber ports, and so as to ensure better supplies for home consumption, exports to other than Allied countries are likely to be reduced considerably. House coal, as is expected in milder weather, is not so much in request as a week ago, and collieries are able to work off as much of their arrears as the irregular transport arrangements will allow. The large number of coke-ovens in use are absorbing practically all of the supplies of small fuel, and could do with a larger tonnage, if available. This market is at present in an unsettled condition. Exports of coal for coking purposes are being prohibited by the Government, who are taking this action with a view to increasing the quantity of by-products for high explosive manufacture. Inland works are taking big tonnages of gas fuel on contract account. Practically no tonnage of slacks is available on the open market, this fuel being in short supply. A good inquiry is experienced for blast-furnace coke, which is firm at the maximum rate of 24s. per ton, on rail at the ovens. Quotations:—Best branch hand-picked, 20s. 6d. to 21s. 6d.; Barnsley best Silkstone, 17s. 6d. to 18s. 6d.; Derbyshire best brights, 17s. 6d. to 18s. 6d.; Derbyshire house, 16s. to 17s.; best large nuts, 15s. to 16s.; small nuts, 14s. 6d. to 15s. 6d.; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 11s. to 12s.; seconds, 9s. 6d. to 10s. 6d.; smalls, 8s. to 9s.

Iron and Steel.—A substantial expansion is evident in the aggregate output of the local steel works since the commencement of the year. Although hundreds of workmen have been brought from military service, there is still a shortage, mostly of mechanics. This scarcity of labour also, however, applies to clerks, who have enlisted in large numbers, but their places are being rapidly filled by young women. Few firms, other than the big armament and munition houses, are engaging factory women, and a large supply of these are now available. The fixing of maximum prices of pig-iron is causing a good deal of uncertainty, and the market is in an unsettled condition. Makers, generally speaking, are unable to enforce the maximum figure, which is at a much higher level than was anticipated. Quotations for Derbyshire foundry, with a maximum of 87s. 6d., are still round about 80s. to 82s. 6d. on truck. Forge iron is 2s. to 2s. 6d. below these figures. Makers, in quoting, however, have practically no fixed rate, and prices vary considerably. The maximum is being asked for basic qualities by Lincolnshire producers, but as in Derbyshire brands forge and foundry iron is being sold below that figure at 82s. to 83s. on truck. East Coast mixed numbers of hematite are quoted from 133s. to 135s., and although there is not much actual business being done outside contracts, both special and ordinary qualities are being consumed in enormous quantities. No improvement is reported in the supply of steel billets, quotations being nominal, and everything is dependent upon deliveries. The latest quotations are:—Bessemer acid, 14*l.* 10s.; Siemens acid, 15*l.* 10s. to 16*l.*; hard basic, 13*l.*; soft basic, 12*l.* to 12*l.* 10s. The demand for steel scrap is very heavy, and prices are steadily advancing. Considerable extensions are being made to rolling-mills. Two sets of rod-mills erected by one firm are of 12-in. and 14-in. size, the total output being 150 tons of finished rods weekly; each of the mills will be driven by a 175-brake-horse-power gas-engine. Japanese requirements are a strong feature in this week's export demands, and, judging from their nature, that country is considerably extending her manufacturing resources. A large quantity of file-steel is being sent to Japan, and also steel for tools, knives, razors, and other products. Twist-drills, tools, files, cutlery, steel, steel blocks, billets, and saws also figure among orders from all parts of the globe. The latest War Office contracts placed with Sheffield makers include millions of table-knives and forks, files and tools, clasp knives, razors, bill-hooks, and surgical instruments. Steel for cutlery making is difficult to obtain, and work has to be suspended for short periods. Cutlery-makers are strictly ordered to supply the needs of the Allies' armies with 80 per cent. of their output, while the other 20 per cent. can be readily absorbed by the British Colonies alone, so the public of the country are in a somewhat parlous position. Owing to Government pressure makers are advising country customers that they are unable to accept any orders for the duration of the war.

THE BRITISH ELECTRICAL AND ALLIED MANUFACTURERS' ASSOCIATION.—At the monthly dinner of this Association, colloquially known as the "Beama," held on Thursday, January 20, there were present, as guests, Mr. Henry Thornton (general manager, Great Eastern Railway), Mr. S. Z. de Ferranti (Past President, Institution of Electrical Engineers), Mr. Charles H. Merz, Sir George Riddell, Mr. H. E. Morgan, Mr. A. Spencer (Messrs. G. S. Moulton and Co., Limited). Mr. Charles H. Walker, Mr. H. Gordon Selfridge, and Mr. R. F. Gibb (Union-Castle Line). Mr. Thornton, after dinner, opened a discussion on "Commercial Mobilisation," and was followed by Dr. Merz, Mr. Gordon Selfridge, Mr. Colton (the Westinghouse Company), and Mr. Ferranti. We deal with one aspect of the discussion in our leading article.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is steady and active, limited only by the shortage of stocks and scarcity of labour. But for the difficulty in securing men, despatches would be much heavier, both by rail and sea. The wharves and docks are still much congested. The shortage of labour renders increase in production to meet the demand impracticable. Considerable dissatisfaction is expressed with the uncertain position in which the question of maximum prices has been left by the Government. This week a number of sales of No. 3 g.m.b. Cleveland pig have been made at the understood fixed maximum of 82s. 6d., but there is now a feeling that the price may not be limited to that figure. The position has eased somewhat, and the ruling quality can now be bought at 82s. 3d. No. 1 is put at 86s., and No. 4 foundry at 81s. 9d. No. 4 forge is plentiful, and is offered freely at 80s. 9d.; whilst mottled and white iron are each on sale at 80s. All the foregoing quotations are for early delivery, makers still being unwilling to commit themselves ahead to any extent.

Stocks of Pig-Iron.—Makers of pig-iron have little or no iron lying at their yards. Practically the only stock in existence is the Cleveland iron in the public warrant stores, and the quantity held there is, for the first time since September 21, 1914, below 100,000 tons. On that date the stock stood at 99,930 tons. To-night (Wednesday) the quantity in the public warrant stores is 99,121 tons, all of which is No. 3 quality. Since the beginning of the month the stock has been reduced by 13,925 tons.

Hematite Iron.—East Coast hematite pig is very scarce. Little can now be purchased for supply before the third quarter of the year, many makers having disposed of all they can make to the end of June. Some producers are committed as far ahead as they care to be, and are not disposed to quote. A little business has been put through this week at 135s. for May-June delivery of Nos. 1, 2, and 3, but that is more a buyer's than a seller's quotation. As a rule round about 137s. 6d. is now asked for mixed numbers, and up to 140s. has been named. These high prices are checking Sheffield buying, customers in that district being able to place orders more advantageously on the West Coast, but demand on account of our Allies continues very good.

Shipments of Pig-Iron.—Shipments of pig-iron from the port of Middlesbrough are, under all the circumstances, satisfactory. To date this month they average 1235 tons per working day, the total despatches amounting to 25,928 tons. To the same date last month the clearances totalled 33,340 tons, or a daily average of 1600 tons, and for the corresponding part of January last year the loadings were returned at 12,490 tons, or an average of 600 tons per working day.

Foreign Ore.—Values of foreign ore continue to advance, but the amount of business passing is not large. Market rates are based on fully 40s. ex-ship Tees for Rubio of 50 per cent. quality. Heavy supplies continue to come to hand, with the result that consumers have now fairly good stocks and are not keen to enter into further contracts at the high prices ruling. Imports to the Tees so far this month amount to no less than 181,815 tons. Freights, Bilbao-Middlesbrough, are up to 23s. 6d. Steamers have been fixed at that figure, and the prevailing opinion is that freights will be still higher.

Manufactured Iron and Steel.—Government requirements continue to absorb practically the whole of the capacity of the finished iron and steel works, with the result that little attention is paid to ordinary commercial business. The following are among the principal market quotations:—Common iron bars, 13*l.* 10s.; best bars, 13*l.* 17s. 6d.; double best bars, 14*l.* 5s.; treble best bars, 14*l.* 12s. 6d.; packing iron (parallel), 9*l.* 10s.; packing iron (tapered), 11*l.* 5s.; iron ship-plates, 11*l.*; iron ship-angles, 13*l.* 10s.; iron ship-rivets, 15*l.* 10s.; steel ship-plates 11*l.* 10s.; steel ship-angles 11*l.* 2s. 6d.; steel sheets (singles), 14*l.*; steel sheets (doubles), 15*l.*; steel joists, 11*l.* 2s. 6d.; steel strip, 12*l.* 15s.; steel hoops, 13*l.*; heavy steel rails, 10*l.* 17s. 6d. to 11*l.*; and steel railway sleepers, 11*l.* 10s. to 12*l.*—railway material net f.o.b., steel plates, steel ship-angles, and steel joists net at works, and all other descriptions less 2½ per cent. discount.

UNIVERSITY COLLEGE LECTURES.—The Provost announces that, owing to circumstances arising out of the war, Mr. Kilburn Scott's course on "Electrical Production of Nitrates for Fertilisers and Explosives," announced to begin on Wednesday, January 26, will not be held.

"INTERNATIONAL MILITARY DIGEST."—We have received No. 7, Vol. I., for December last of this monthly review of the current literature of military science. It is issued by the "International Military Digest," 241, West Thirty-Seventh-street, New York, the editorial office being at West Point, N.Y. As its title implies, it gives abstracts from journals published throughout the world of articles on all classes of military subjects. In the December issue abstracts on asphyxiating gases, on the European war, on the armies of various nations, on various corps of troops, &c., are specially interesting. One of the editors-in-chief is Colonel C. de W. Willcox, the author of the valuable French-English military technical dictionary. The "Digest" is issued monthly at the price of 3 dols. per year, or in quarterly issues at 5 dols. per year.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has shown continued firmness. With free arrivals of tonnage, and colliery-owners heavily booked for all descriptions, sellers of small parcels were able to maintain strong terms; strong conditions are also anticipated in February. The best Admiralty large steam coal has been, to some extent, nominal; secondary descriptions have made 31s. 6d. to 32s. 6d.; best bunker smalls, 18s. to 19s.; and cargo smalls, 12s. to 13s. per ton. The best household coal has realised 23s. to 24s.; good households, 21s. to 22s.; No. 2 Rhondda large, 27s. to 28s.; and No. 2 smalls, 15s. to 16s. per ton. The latest quotation for patent fuel has been 28s. to 30s. per ton. Special foundry coke has made 42s. to 45s.; good foundry coke, 38s. to 42s.; and furnace coke, 33s. to 35s. per ton. As regards iron ore, Rubio has brought 36s. to 37s. per ton upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

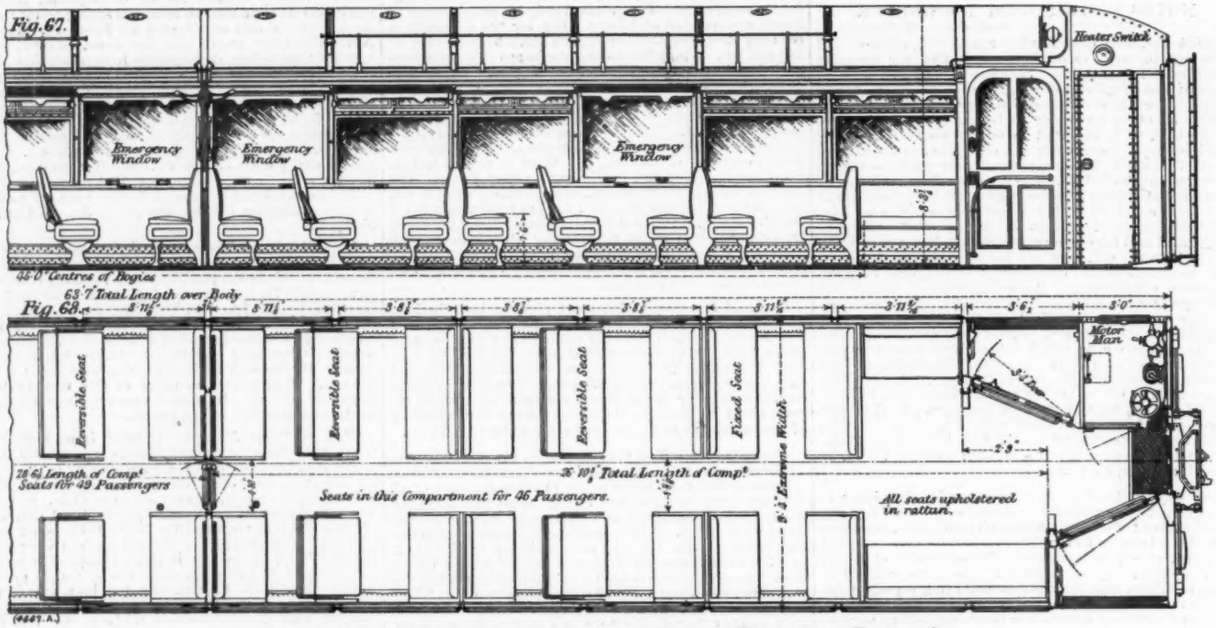
Local Burdens.—The rates levied in some of the principal western towns in 1915-16 are returned as follows:—Bristol, 8s. 4d. in the pound; Bath, 7s. 11d.; Gloucester, 7s.; Cardiff, 7s. 9d.; Exeter, 7s. 3d.; Plymouth, 7s. 3d.; Merthyr Tydfil, 10s. 9d.; Swansea, 9s. 6d. At Bristol the docks add about 1s. in the pound to the rates. Portsmouth has a water and dock charge of 1s. 10½d. in the pound. Gloucester has to pay 4d. in the pound for trams. Profits and rents, however, also assist municipalities. Bristol obtains relief in this manner to the extent of 3¾d. in the pound annually, and Gloucester to the extent of 7¾d. in the pound.

Western Trade Matters.—Exports from Port Talbot docks have been ranging of late at from 45,000 tons to 50,000 tons per week, coal and coke figuring in these totals for about 42,000 tons. The profits of the Llandudno Pier Company for the past year were 314*l.*, and 1102*l.* was brought into the accounts from 1914. A dividend of 12½ per cent. is proposed for 1915; 1142*l.* being carried forward. The directors of the Alexandra (Newport and South Wales) Docks and Railway Company recommend dividends of 4½ per cent. upon the A and B preferred stocks. Mr. A. T. Cotton, who has been appointed to succeed Mr. J. A. Findlay as superintendent of the London and North-Western Railway, for the South Wales district, with head-quarters at Abergavenny, has been for twenty-four years superintendent at Belfast for the London and North-Western Company, the Lancashire and Yorkshire Railway, and the Belfast and Fleetwood Royal Mail service. Mr. Cotton commenced his career with the Belfast and Northern Counties Railway. An instance of the great profits made by shipping companies during the past year is afforded by the Field Line (Cardiff), Limited, managed by Messrs. Evans, Jones and Co. The net revenue for 1915 is returned at 71,392*l.*, as compared with 11,881*l.* in 1914, 27,136*l.* in 1913, and 33,908*l.* in 1912. The directors recommend a dividend of 25 per cent. for 1915, carrying 40,000*l.* to reserve; the dividends distributed for 1914, 1913, 1912, and 1911 were at the rate of 10 per cent. per annum. The net profits of the Cynon Colliery Company for the past year were 27,593*l.* A steel single-deck steamer of 2297 tons gross, built at Sunderland in 1889, and carrying 3700 tons dead-weight, has been sold for 50,000*l.*; she was formerly owned by Mr. G. Hallett, of Cardiff, who disposed of her in October, 1912, for 9000*l.* The Field Line (Cardiff), Limited, has set apart 20,000*l.* out of its greatly increased profits for 1915 to provide for the excess profits tax for the year. During the past month freight rates from Cardiff to Rouen have advanced 3s. per ton; to Lisbon, 4s. per ton; to Gibraltar, 6s. per ton; to Algiers, 8s. per ton; and to Marseilles, 11s. 6d. per ton.—At Pontypridd on Friday the Albion Colliery Company summoned Arthur Burgess, a repairer, for alleged breach of contract by absenting himself on Sunday night, October 31. The point at issue was whether a Sunday-night shift was compulsory or optional. The Stipendiary said he had come to the conclusion that it had been the practice for many years at the colliery to work on Sunday nights, and that the custom had opened into a contract.—The City of Paris, of the Ellerman City and Hall Lines, is about to make a voyage from Newport to Port Said, Bombay, and Karachi; she will load about 3000 tons of coal and other cargo; she will also take passengers, of whom she can carry 170 first-class and 660 second-class. An agreement has been entered into between the Government of Jamaica and Messrs. Elders and Fyffes, Limited, by which a fortnightly mail service will be at once resumed between the Colony and the Mother Country. A Colon call has proved a success, and Messrs. Elder and Fyffes' vessels now carry a Pacific Coast mail.

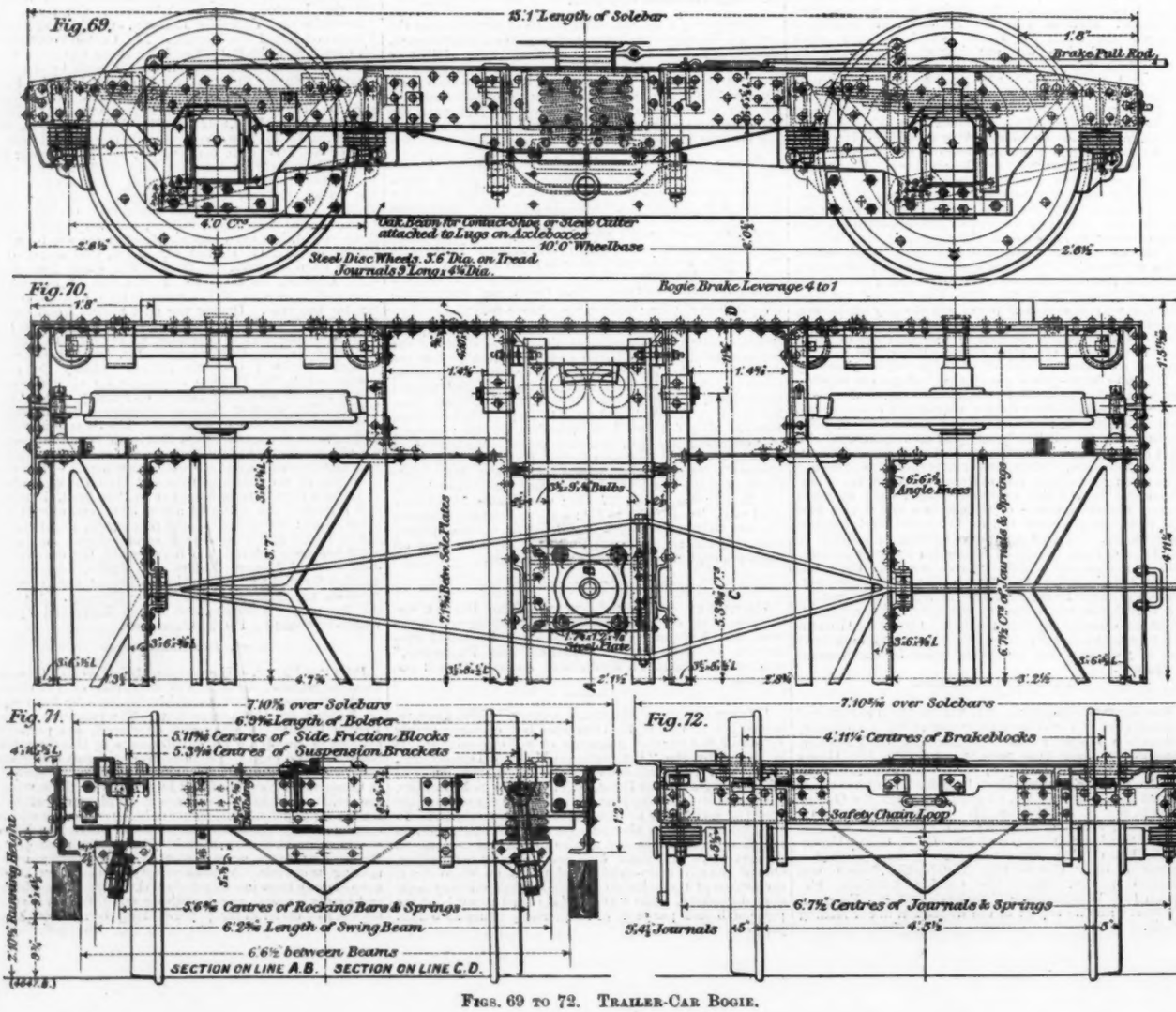
PULP FOR PAPER.—The decision of the Swedish Government to prohibit the export of wood-pulp calls attention to the enormous extent to which this country has relied on Sweden for this commodity. The resources of the British Empire, if adequately developed, are perfectly capable of supplying all our demands in this direction. Swedish wood-pulp is produced from the soft coniferous woods, such as the various kinds of fir, pine and spruce; in Canada and Newfoundland huge areas of these woods are still untouched, the present employment of this timber for paper-making purposes being on a scale which, compared with the natural resources of these Dominions for the purpose, is quite trivial. Many other parts of the British Empire are, moreover, capable of supplying paper-making materials. A great variety of these materials have already been investigated at the Imperial Institute, and hardly a month passes without fresh British sources for the raw material for paper-making being brought to light.

ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION; L. AND Y. RAILWAY.

(For Description, see Page 80.)



FIGS. 67 AND 68. LONGITUDINAL SECTION AND PLAN OF THIRD-CLASS TRAILER-CAR.



FIGS. 69 TO 72. TRAILER-CAR BOGIE.

ONE OF THE NEW BRITISH PROJECTILE-MAKING FACTORIES.

(*For Description, see Page* 76.)

FIG. 5. SMALL-SHELL PRESS SHOP.

FIG. 6. LARGE-SHELL PRESS SHOP.

(*To Face Page* 78.)

ONE OF THE NEW BRITISH PROJECTILE-MAKING FACTORIES.

(*For Description, see Page 76.*)

FIG. 7. HYDRAULIC FORGING-PRESS FOR THE LARGEST SHELLS

FIG. 8. MACHINE-SHOP FOR LARGE SHELLS.

ONE OF THE NEW BRITISH PROJECTILE-MAKING FACTORIES.

(*For Description, see Page* 76.)

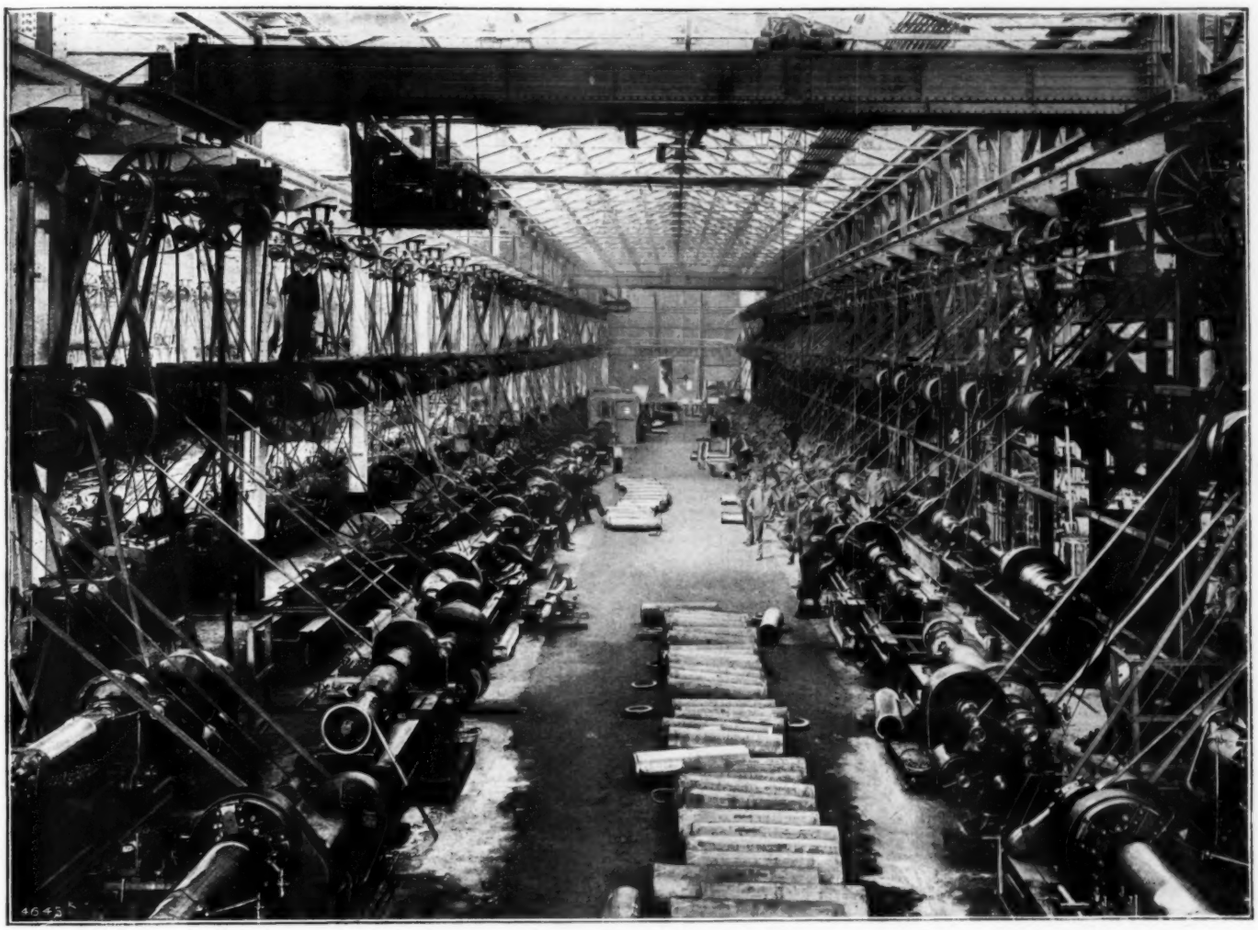


FIG. 9. MACHINE SHOP FOR LARGE SHELLS.

FIG. 10. MACHINE-SHOP FOR MEDIUM-SIZE SHELLS.

ONE OF THE NEW BRITISH PROJECTILE-MAKING FACTORIES.

(*For Description, see Page 76.*)

FIG. 11. PRESSING COPPER BANDS ON LARGE SHELLS.

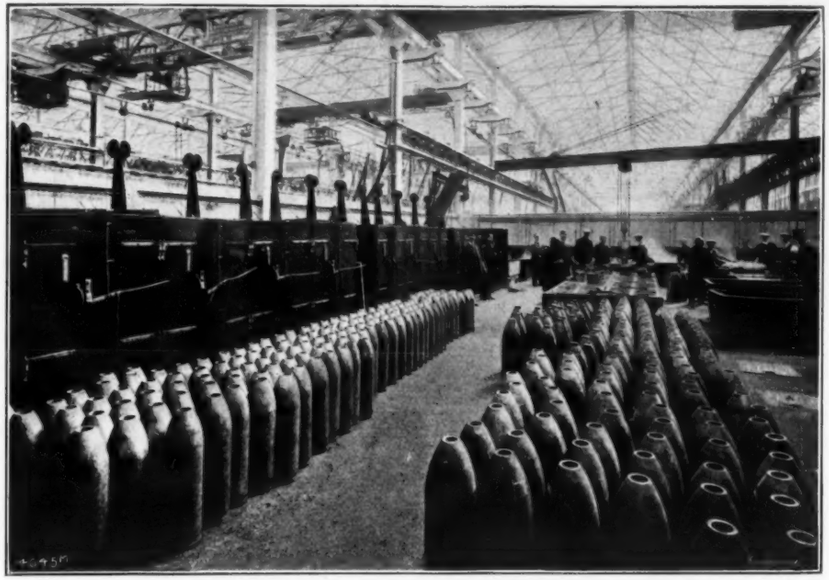


FIG. 12. VARNISHING INTERIOR OF SHELLS.

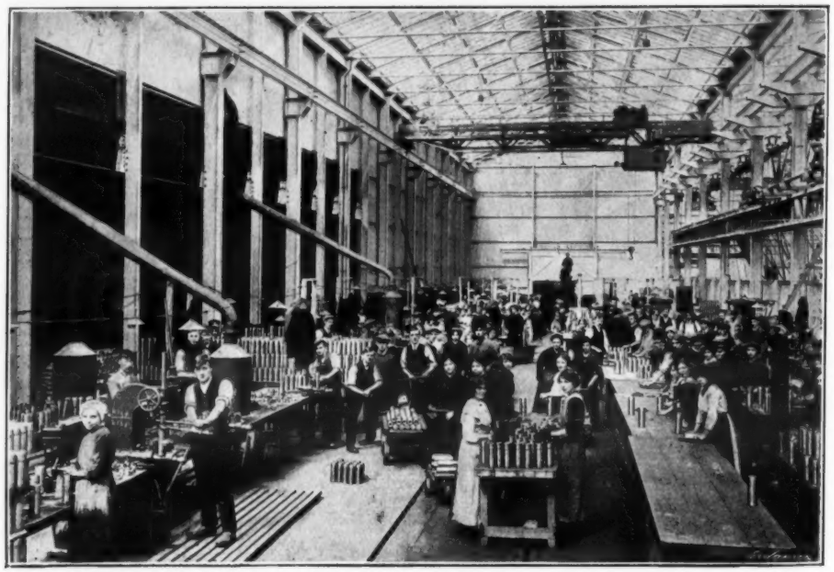


FIG. 13. ASSEMBLING SMALL SHELLS.

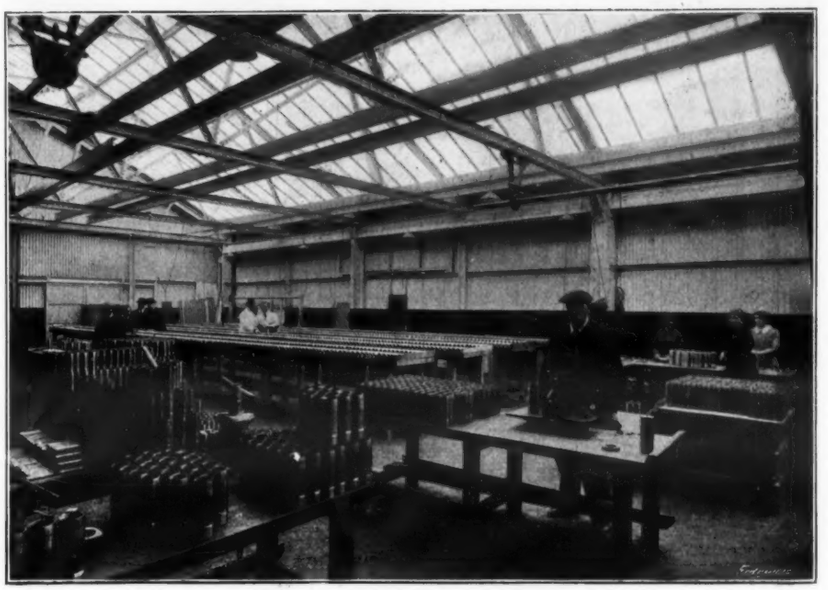


FIG. 14. INSPECTING SMALL SHELLS.

ONE OF THE NEW BRITISH PROJECTILE-MAKING FACTORIES.

(*For Description, see Page 76.*)

FIG. 15. INSPECTING LARGE SHELLS.

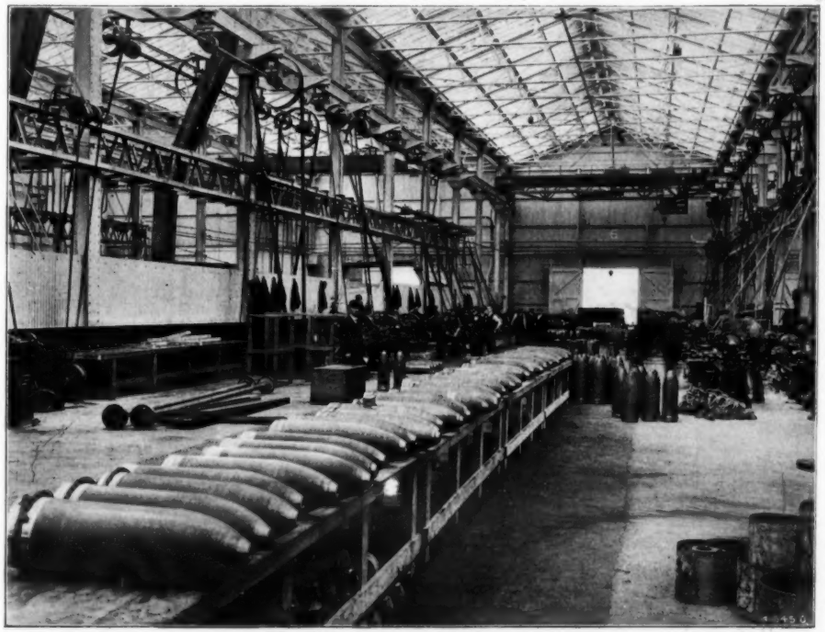


FIG. 17. COMPLETED SHELLS.

FIG. 16. INSPECTING LARGE SHELLS.

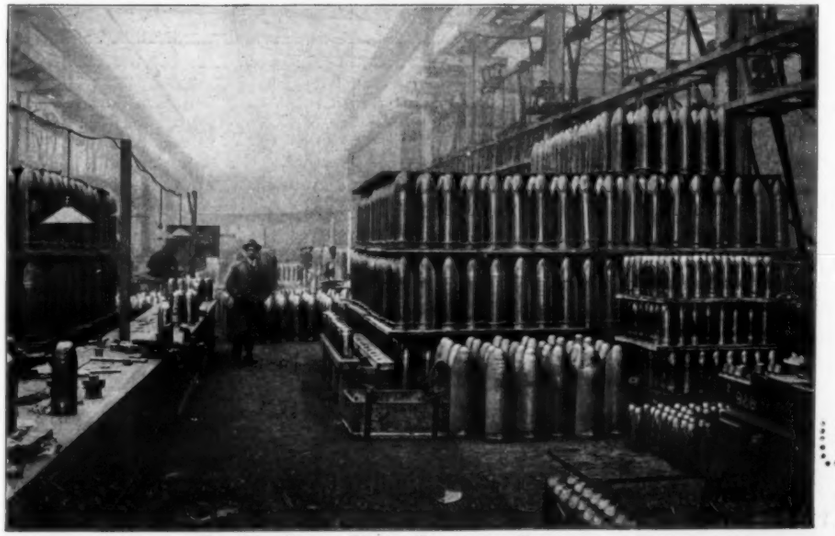


FIG. 18. LARGE SHELLS READY FOR DESPATCH.

ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION OF THE LANCASHIRE AND YORKSHIRE RAILWAY; UNDERFRAME OF MOTOR-CAR.

(For Description, see Page 80.)

Fig. 43.

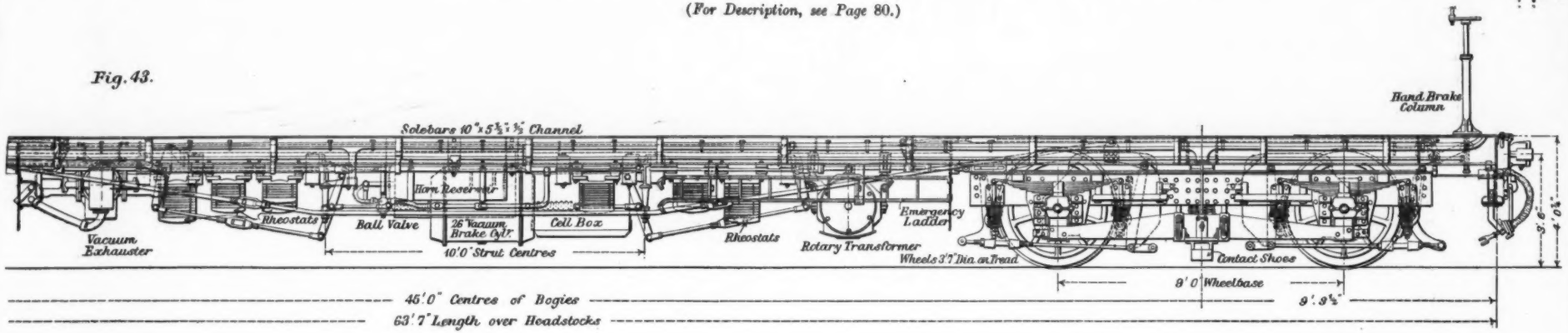
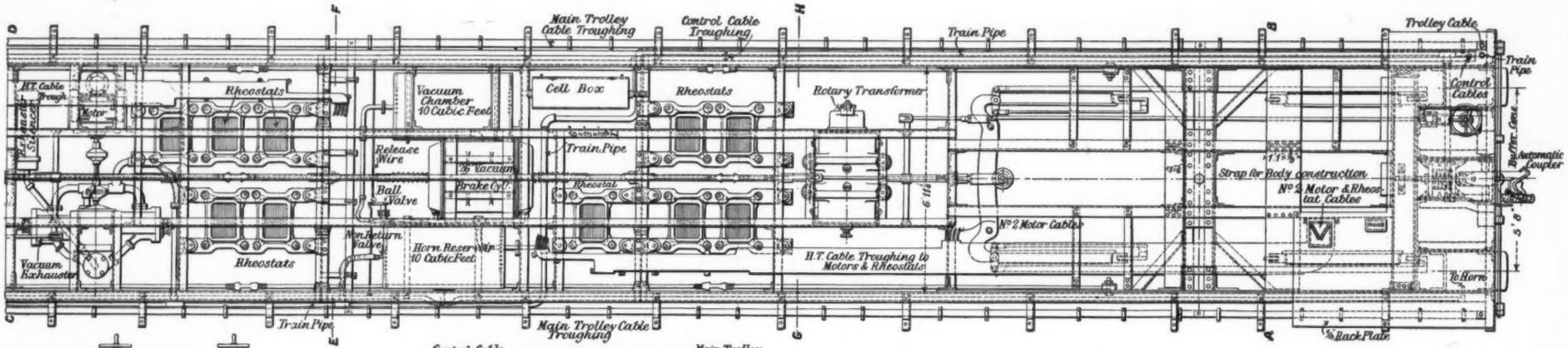


Fig. 44.



END ELEVATION Fig. 45.

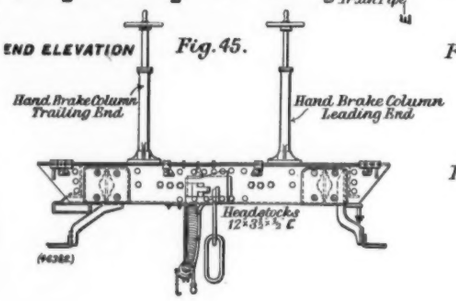
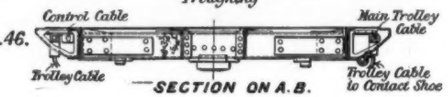
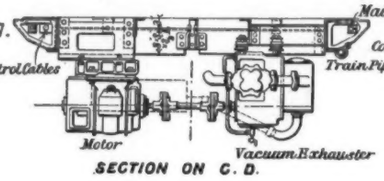


Fig. 46.



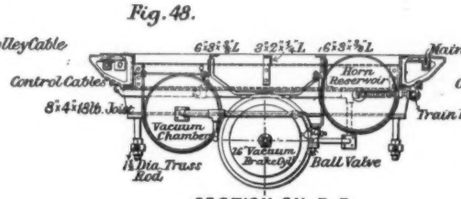
SECTION ON A.B.

Fig. 47.



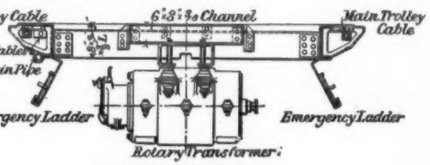
SECTION ON C.D.

Fig. 48.



SECTION ON E.F.

Fig. 49.



SECTION ON G.H.

ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION OF THE LANCASHIRE AND YORKSHIRE RAILWAY; DETAILS OF MOTOR-CAR.

(For Description, see Page 80.)

MOTORMAN'S & HIGH TENSION COMPARTMENTS. BACK ELEVATION.

Fig. 50.

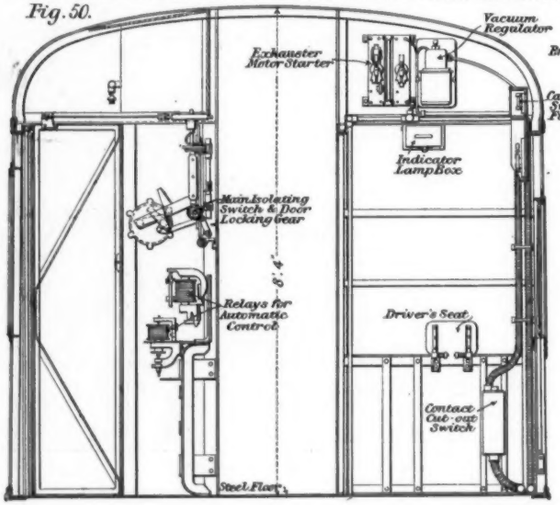
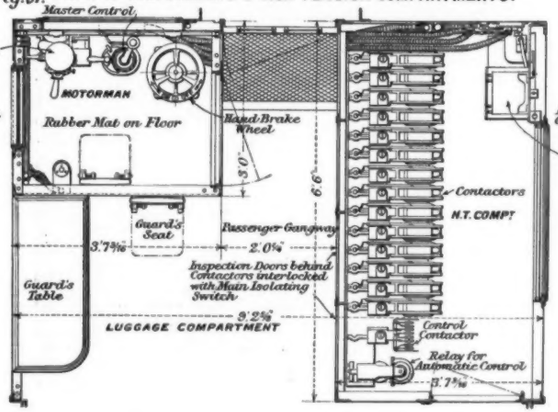
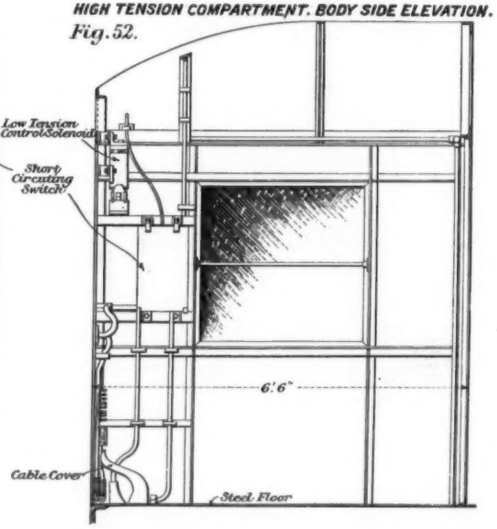


Fig. 51. PLAN OF MOTORMAN'S & HIGH TENSION COMPARTMENTS.



HIGH TENSION COMPARTMENT. BODY SIDE ELEVATION.

Fig. 52.



MOTORMAN'S COMPT BODY SIDE ELEV.

Fig. 53.

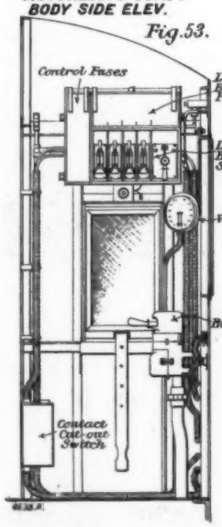
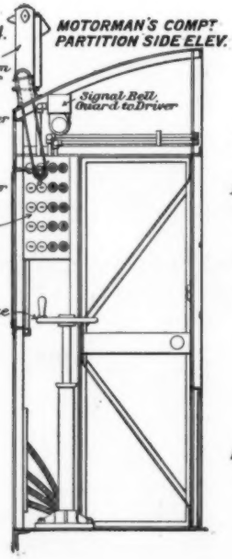
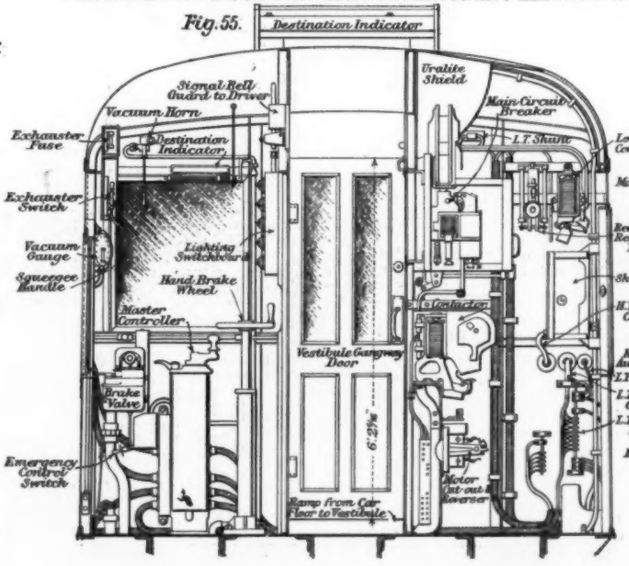


Fig. 54. MOTORMAN'S COMPT PARTITION SIDE ELEV.



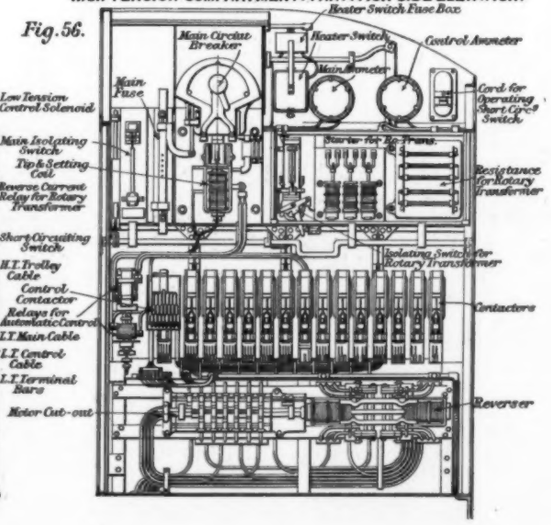
MOTORMAN'S & HIGH TENSION COMPARTMENTS. FRONT ELEVATION.

Fig. 55.



HIGH TENSION COMPARTMENT. PARTITION SIDE ELEVATION.

Fig. 56.



ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION OF THE LANCASHIRE AND YORKSHIRE RAILWAY.

(*For Description, see Page* 80.)

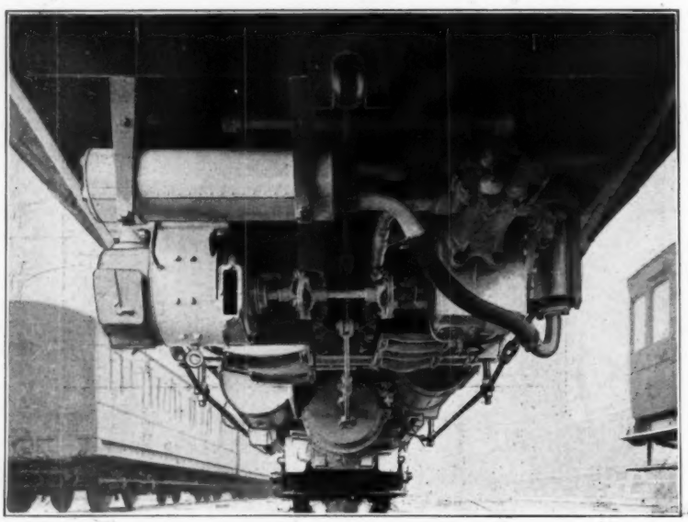


FIG. 57. VIEW OF UNDERSIDE OF MOTOR-CAR.

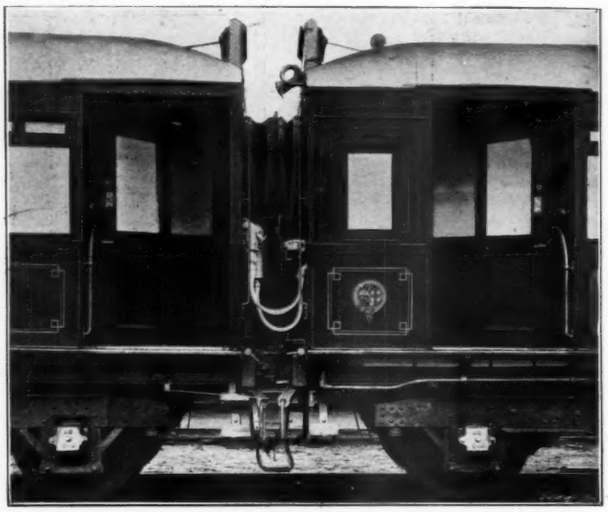


FIG. 58. VIEW OF COUPLINGS, VESTIBULES, AND CABLE COUPLERS.

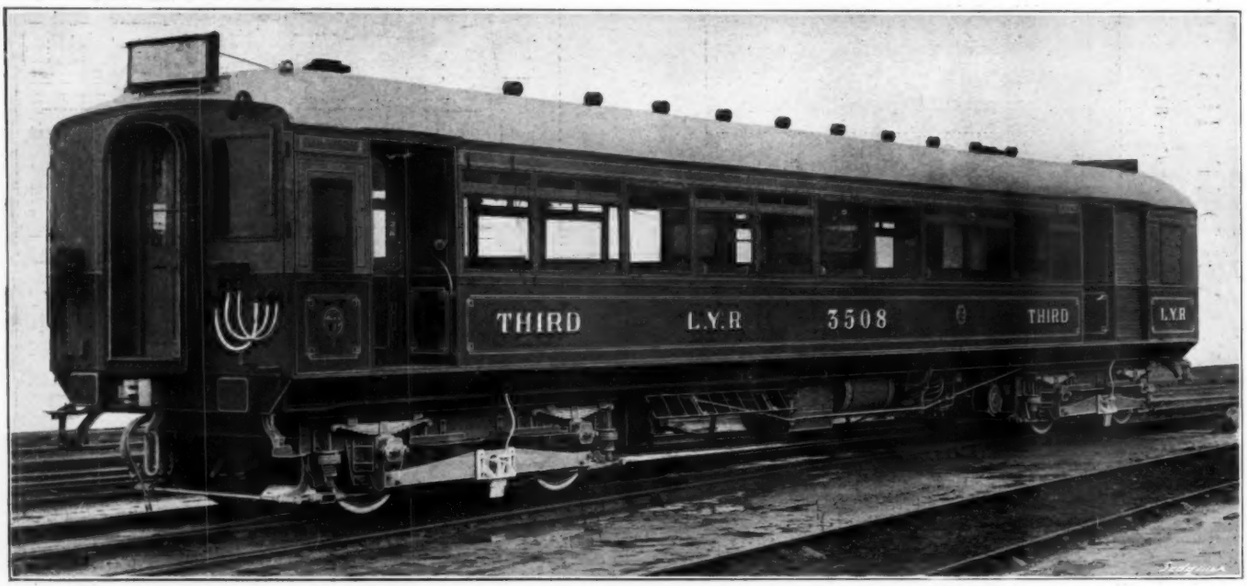


FIG. 59. GENERAL VIEW OF THIRD-CLASS MOTOR-CAR.

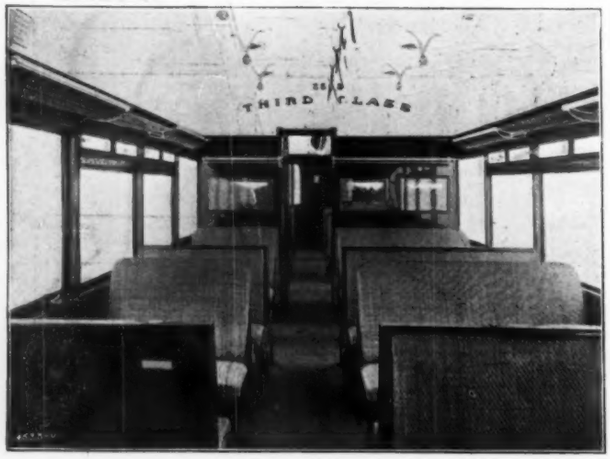


FIG. 60. INTERIOR OF THIRD-CLASS MOTOR-CAR.

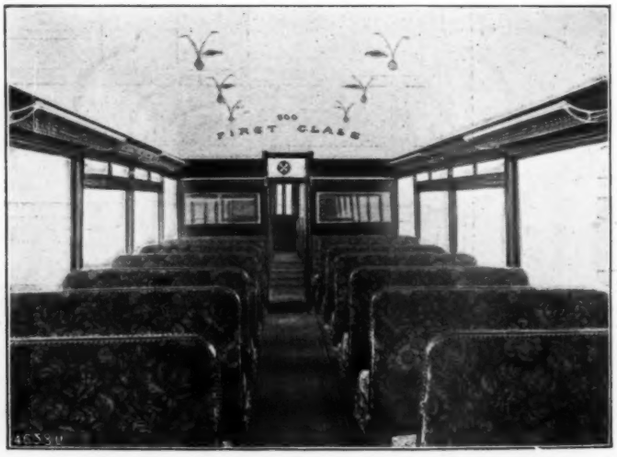


FIG. 61. INTERIOR OF FIRST-CLASS TRAILER-CAR.

(*To Face Page* 79.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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With Five One-Page Plates of ONE OF THE NEW BRITISH PROJECTILE-MAKING FACTORIES; and Three One-Page Plates of the ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION OF THE LANCASHIRE AND YORKSHIRE RAILWAY.

NOTICES OF MEETINGS.

THE NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, January 28, at 7.30 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-on-Tyne, the following papers will be dealt with as indicated. Resumed discussion on "The Time Element and Related Matters in Some Ship Calculations," by Professor J. J. Welch, M.Sc., M. Inst. C.E., Member of Council. To be read and, time permitting, discussed:—"The Standardisation of Stability Curves," by Mr. Wilfrid Ayre, Associate Member.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS (INCORPORATED).—Tuesday, February 1, at 2.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, London. Annual report and election of officers. Afterwards there will be an impromptu discussion, the subjects to be introduced by Members of the Council.

THE RÖNTGEN SOCIETY.—Tuesday, February 1, at 8.15 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. Dr. Sidney Russ will open a discussion on "The Injurious Effects Produced by X Rays." Dr. Herschell Harris will give a demonstration of lantern-slides obtained in Gallipoli.

THE INSTITUTUTE OF SANITARY ENGINEERS.—Wednesday, February 2, at Caxton Hall, Caxton-street, Westminster. Subject:—"The Activated Sludge Process of Sewage Purification," by Professor G. J. Fowler, D.Sc., F.I.C. Illustrated with lantern-slides. Mr. S. A. Self, Chairman of Council, will take the chair at 7 p.m. Discussion to follow.

THE ROYAL SOCIETY OF ARTS.—Wednesday, February 2. A paper on "Women's Work During and After the War" will be read by the Hon. Lady Parsons. Mr. Dugald Clerk, D.Sc., F.R.S., Chairman of the Council, will preside. The chair will be taken at 4.30 p.m.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, February 4, at 5.30 p.m., the discourse will be delivered by Professor W. Bateson. The subject is "Fifteen Years of Mendelism." Afternoon lectures next week at 3 o'clock. Tuesday, February 1. Professor Charles S. Sherrington, M.D., LL.D., D.Sc., F.R.S., Fullerian Professor of Physiology, R.I., on "The Physiology of Anger and Fear" (Lecture III.). Thursday, February 3. Professor W. A. Bone, D.Sc., Ph.D., F.R.S., on "The Utilisation of Energy from Coal: Industrial Applications of Gaseous Fuels Derived from Coal" (Lecture III.). Saturday, February 5. Sir Sidney Lee, D.Litt., LL.D., on "The Shakespeare Tercentenary: the Range of Shakespeare's Influence" (Lecture I.).

ENGINEERING.

FRIDAY, JANUARY 28, 1916.

CO-ORDINATION OF RESOURCE FOR OUR EXPORT TRADE.

WE are apt to talk of the war as a passing phase of affairs, as a phenomenon that will continue for a relatively short time, and will then disappear to give place to a peace free from the horrors and sufferings of the last eighteen months. But in doing so we forget that national life is a warfare, and that there are other agencies than explosives and cold steel by which a people may be displaced from its position in the world. If we recall these facts, our wonder grows that Germany should have abandoned a method of attack, in which she had attained a measure of success never seen in the same time in the world before, for the ruder and less certain chances of the physical battlefield, upon which she ventured not only her expensively-won place in the sun, but also her rapidly-growing commercial position. That she did so is evidence of her inability to understand her neighbours and the world in general. Everywhere she had found a fair field for her commercial efforts. In England her sons had been treated as the equals of loyal subjects of the Crown, although she had endeavoured to shut British products out of her own markets, and in most other countries she had the advantage of the "most-favoured-nation" clause equally with ourselves. As long as she played the game, as it is understood commercially, German business men were free to enter all markets and to make their profits wherever they could, without creating any ill-will. But immediately Germany, impatient of the fruits of steady toil, threw her sword into the scale, demanding that it should be recognised as more than the equivalent of the products of peace, the chief countries of Europe replied by flinging their weapons into the opposite scale, declaring they would only traffic steel for steel and blood for blood. They had raised no opposition to peaceful penetration; Russian commerce and manufacture were largely in Teutonic hands; France acted as host to thousands of those who invaded her in 1870; German names were found in our Privy Council and were numerous on the Stock Exchange, while every large city had its German suburb. But the methods of Prussian autocracy were felt to be unendurable, and even little Belgium, with its relatively insignificant resources, threw itself at the gigantic invader rather than accept serfdom as the price of peace.

The scale has not kicked the beam. As a means of national aggrandisement the action of the Kaiser has proved a complete failure, and the only question that remains open is how cheaply he can withdraw. Even if peace were made to-day, Germany would emerge poorer in men, in money, and in credit, and each month that the war is prolonged the greater will be the material loss to her. But if the lessons of history can be relied upon, she may find an equivalent in other ways. Napoleon beat Prussia to the ground. He ill-treated her, robbed her, insulted her. And in doing so he made her a nation, as he found at Leipzig and Waterloo. Our methods do not follow the Napoleonic tradition, but yet defeat—whether partial or complete—carries its own sting, and spurs a virile nation to increased effort. Already we can see from the German newspapers that the leaders in commerce realise that the sword has failed them, and that they must apply themselves again to the methods which were so successful in the past, even if they were not rapid enough for the military party. The question of the renewal of export trade after the war is being debated in all the great centres of activity, and committees are being formed to elaborate schemes and to secure the compliance and assistance of individual firms. It is said that stocks are being accumulated ready to be dumped in all markets; but one would like more evidence before believing that, since stocks of goods lock up capital very inconveniently, and capital is scarce. However that may be, it is certain that peace will find the German nation prepared with plans for re-entering the markets of the world as far as it is possible, and that the matter will not be left to individual effort, but that it will rest on the combined action of the Government and of all classes engaged in manufacture and commerce. Those who are inclined to play for their own hand will be restrained, and those who hang back from selfish reasons will be stimulated to action, in order that the movement may gain all the advantages of an orderly and co-ordinated advance upon well-considered lines.

Peace will also find us in a chastened condition, for the blood which has been spilt cannot be gathered up, and the labour which has been spent cannot be recovered. But will it find us ready to avail ourselves of the unique opportunity that will present itself? Shall we continue our traditional policy of muddling through? It has served us indifferently well in the war because it has been pursued behind the protection of the Navy. With that impregnable rampart in front of us we can pile mistake on mistake, and add delay to delay without realising the horrors of war in our own land. But once peace is signed the Fleet cannot close the neutral markets of the world to our enemies, and unless very different counsels prevail here, it cannot guard our own. Then we must rely solely on our own skill to measure swords with an antagonist who has many scores to pay off, and who will take full advantage of every mistake. At the commencement of the war the papers spoke as if the trade of the world was already in our hands, but soberer ideas have got abroad since, and the public is beginning to realise that the problem is bigger and more difficult than they had thought, and that commerce is a science that needs much study for its understanding, and the best brains for its management. There is a demand for a plan of campaign, as is evidenced by the fact that the Lord Mayor has called a meeting for the 31st inst. to discuss the subject, and by the numerous committees of more or less capable persons who are endeavouring to frame a programme. They are all met by the initial difficulty of determining the conditions under which the campaign will open. That there will be an immense demand is certain, for the requirements of the world will have remained unfilled for two or three years, and all its wear and tear unremedied. Further, the ravages of war will have destroyed millions of pounds' worth of property, such as railways, bridges, workshops, and the like, that will be urgently needed. There will be orders to fill every iron works and shipyard and engineering works in the countries of the Entente, and the only difficulty will be regarding the terms of payment. Then will come the day of the ready-money capitalist. He will be able to make splendid bargains with needy borrowers, and to obtain controlling interests in concerns crippled for want of funds, on quite exceptional terms. But there will be a limit to assistance of this kind, for the Government is taxing manufacture up to the hilt, and very little is being saved. Much of that is being patriotically lent to carry on the war. It is perhaps as well that there should not be such a boom of prosperity as followed the Franco-German War, for if there were it is quite certain

that there would be no organised and systematic effort to secure the markets of the world. Each manufacturer and merchant would fill his order-books at the best prices obtainable, without adopting new methods, and when the boom was spent we should be as little prepared for commercial warfare as we were for the military struggle.

The truth is that as a nation we hate constructive thought. The policy of "wait and see" appeals to us most forcibly, although in the past it has generally been disguised as the appointment of a committee or of a Royal Commission, and has not been proclaimed boldly from the Treasury bench. But the committees have generally consisted of men of official standing who knew nothing of the actual matter in hand, and who could only decide judicially after calling more or less evidence. Their decisions, right or wrong, had no compelling power in them. They were like a clock, with no one interested in winding it up, and generally they were about as useful. Things are done differently in other lands. Mr. H. W. Thornton, the General Manager of the Great Eastern Railway Company, related at a dinner of the British Electric and Allied Manufacturers' Association, on the 20th inst., what is being done in America to secure a share of the German trade. He said that a corporation had been formed with a capital of 10 millions sterling, entirely by private enterprise and without any reference to the Government. This corporation does not represent one set of manufacturers or a selected set of manufacturers, but comprises all the interests necessary for pushing a great export trade. There are included in it manufacturers, of course, but there are also merchants, selling agencies, bankers, railroads, and shipping interests. The trade is to be taken care of from the works, or the mill, right to the foreign ports, and is not to be confided *en route* to agencies which have no interest in it, or have a direct interest in delaying it. Such a corporation is scarcely possible in this country, but the ideas of its founders are well worth study, They show that in the opinion of some of the keenest men in America the days of individualism are past, and that commercial warfare can only be conducted on the same principles as military warfare—that is, by concerted action in which the individual seeks his reward by furthering the interests of the community, or of the corporation to which he attaches himself. The inclusion of bankers in the scheme is noticeable. Many of the members of the corporation, such as the Armour Company, the Standard Oil Company, and the transcontinental railways, are possessed of immense resources, but nevertheless they seek further monetary aid, and, what is more important, the skill and knowledge of men versed in finance. If any great success is to crown our efforts here to capture new markets, the bankers must bear their part in the struggle. Hitherto they have been the spoiled children of finance, and have gathered where they have not strawed. The main business of the London banks lies in buying bills with their clients' money. These bills always bear two names, and often more, and if they represent goods at sea, they have the underwriters behind them. It is a safe and a lucrative business, and, so far as it goes, it greases the wheels of commerce. But it is a cosmopolitan trade; bills come to London from all parts of the world, and they are equally welcome if they represent a cargo of electric machinery *en route* from Berlin to Buenos Aires, a shipload of nitrates from Chili to Hamburg, or a consignment of calico from Manchester to Canton. In any case we gain a profit, but in the first the money enables the foreign manufacturer to start immediately on a second consignment on better terms than if he had to raise the means in Berlin. We should be surprised to learn that the Deutsche Bank discounted bills representing hardware from Birmingham or rails from Middlesbrough.

Banks, of course, are not philanthropic institutions, not even nationally philanthropic, and they are not likely to abandon a safe and profitable trade unless they are obliged, or can replace it with something equally good. It is scarcely likely that after the war any bank will endanger its reputation by lending money on bills emanating from the Central European Powers, and this fact alone will set free a good deal of money. Further, the assistance afforded by the Government to the banks during the first months of the war will give the former the right to dictate, to some extent, the policy to be followed in the future. This need not entail any loss if the banks avail themselves of the best technical advice, as does the Deutsche Bank, but it will involve a good deal of trouble and study on the part of the directorates. The matter is one for grave consideration, but in some way or other the assistance of the banks must be assured if we are to be successful in the coming commercial warfare.

At the dinner above referred to some very excellent advice was given to the members of the Association by Dr. Merz and Mr. Ferranti. It was, of course, specially addressed to electrical engineers, but it has an application in a wider field. It was to the effect that success in export can only be attained as a corollary to success in the home market. It was because we equipped our own land with railways that we were able to build railways in many other countries. The creation of a great textile industry brought us orders for cotton and wool machinery from Europe, India, China, and Japan. We led the world in sanitation, and our appliances have gone all over the globe. But we have no record like that to show in electric engineering, apart from submarine cables. The industry was starved in its infancy by the interference of the municipal traders, and after more than thirty years it is but a weakling, unable to meet its foreign enemies abroad, and not always at home. It may do better under the new conditions, but with a fairer start it would now have been in a lusty manhood, able to hold its own in any company. For it, and for many other industries, salvation lies in specialisation in manufacture and in co-operation in selling. Costs of production must be kept down by large outputs in a narrow field, while costs of selling must be reduced to a minimum by the co-ordination of bankers, selling agencies and transport companies. It is this latter point that ought to engage the attention of the Lord Mayor's meeting, and if there results from that gathering a committee of real business men, with wide experience and the ability to command confidence in their decisions, who will devote themselves to providing efficient means of communication between the manufacturer here and the customer abroad, we can face the future without misgiving. It is at the selling end that England is weak and Germany is strong, just because individualism runs mad here, while it is restrained there. We need to have the fact ground into us that what is good for the hive is good for the bee, and to learn that the best opportunities for making money are to be found in a prosperous community. There will never be a better time to preach that gospel than the present, when the future is full of uncertainty, and while it is imperative to make provision to meet the unknown. During the last eighteen months we have had one disillusionment after another, until we feel all grounds of certitude slipping from beneath our feet. We need to reconstruct our methods and beliefs in many things, and in none more drastically than in our foreign trade.

LESSONS OF THE WAR APPLIED BY THE AMERICAN NAVY.

ALTHOUGH it is impossible in the absence of complete data to make now full and definite deductions from the naval operations during the war, those neutral countries who must continue naval shipbuilding work are compelled by the necessities of the case to analyse the strategical and tactical operations as best they can in order to apply in new ships the lessons derived from such analysis. Of the neutral Powers, the United States of America is unquestionably the most important, and one therefore looks with expectancy to the proposals of Admiral Dewey's general board of "naval statesmen," and to the Report to Congress of the Secretary of the Navy, Mr. Josephus Daniels, embodying the proposals of the Navy Department regarding new construction. This report is of far greater significance than usual, because, for the first time, there is advocated by the Secretary to the Navy a continuous programme of new construction extending over five years. Admiral Dewey has for many years recommended this course, but only last year were the public made aware of this fact. Now, however, the Department has officially accepted the proposal, and it remains for Congress to determine whether it shall be carried into effect. In laying down the number and types of ships to be embraced in this quinquennial programme, the policy enunciated by Admiral Dewey is to make the navy of the United States by 1925 equal to the most powerful maintained by any other nation in the world; because the course of the present war in Europe has afforded convincing reasons for modifying the opinion expressed for the past eleven years as to the proper size of the navy. "The current war has shown that a navy of the size recommended by this Board in previous years can no longer be considered as adequate to the defensive needs of the United States." . . . "A Navy in firm control of the seas from the outbreak of war is a prime essential to the defence of a country situated as is the United States, bordering upon two great oceans." In addition to defence from invasion, the aim is to protect American sea-borne commerce, and to drive that of the enemy from the sea. In other words, it would almost seem as if America proposed to challenge our sea supremacy so far as preparedness for its maintenance during war is concerned. This challenge, however, we regard with equanimity, because a conflict between ourselves and the United States is unthinkable, and, in any event, it seems doubtful whether the aim of Admiral Dewey can be realised. The Secretary of the Navy does not go quite so far, although he adopts the complete programme with slight modifications only in respect to auxiliary ships. He is probably conscious of the immense need for educating the great proportion of residents in the interior of the United States as to the importance of sea-power. No doubt this education will be stimulated if, as is possible, the merchant marine of the United States increases greatly owing to present war operations.

Sea-power means more than the mere building of warships and the maintenance of them, and, appropriately enough, Mr. W. S. Abell, the Chief Ship Surveyor of Lloyd's Register, dealt very thoughtfully with this problem in his James Watt lecture. He was right in contending that sea-power was dependent on natural conditions, and that the navy which possesses those natural conditions to the fullest extent, and has the capacity to use them to the greatest advantage, will, of necessity, enjoy the fruits of sea-power. Geographical conditions affect the question. A situation remote from world trade routes is very disadvantageous. It is probably this theory which has made Germany particularly anxious to have more direct contact with the North Sea and the English Channel. Mr. Abell pointed out that the greatest proportion of land, density of population, and deposits of coal and iron, all conducive to commercial expansion, occur in the northern sphere, somewhere between 30 deg. and 60 deg. north latitude. Consequently the carriage of raw materials and the export of manufactured articles will naturally focus on narrow sea frontiers in this area, and, naturally, the proximity to a nation of these sea frontiers is an immense advantage in the maintenance of the sea power of such nation. Physical characteristics are also operative, and by reason of her insular position, and her dependence upon sea transport, Britain has further advantage. Moreover, our natural mineral wealth encourages manufactures and export trade, and the absence of such raw materials as cotton, wool, vegetable oils, and even timber, encourage import trade. These trade advantages, combined with a high density of population, assist towards the development of commercial maritime interests. Moreover, our capacity in commerce and our faculty in colonisation, combined with freedom of Government, tend to affect the question, and in large measure to justify Mr. Abell in the conclusion that unless sea-power is firmly based upon such natural conditions, any manifestation of power can only be of an "ephemeral" character. The burden of sea-power is much more readily carried when there is a healthy commerce and a large and well-employed mercantile marine, as well as colonies to provide points of protection and shelter, and to enlarge facilities of exchange. As we have said, the immense population in the interior of the United States fail to grasp the importance of the maritime industry; so that for this reason, as well as for the ties of kinship, we do not regard with any misgiving the proposals of the Americans for a larger navy.

Interest in the new five-year programme is naturally concentrated in the type of vessel which it is proposed to build. Admiral Dewey states that "the conclusion to be drawn so far from the history of the current war is that the battleship is still the principal reliance of navies as it has been in the past," and consequently it is proposed to lay down two battleships in each of

the next five years, which would bring up the number of battleships built or building in 1921 to fifty-two, excluding, of course, vessels which have then become obsolete. As the estimated cost of each of these ships is 3,760,000*l.*, it is obvious that they are to be of immense power. The latest ships, laid down under last year's programme, are to be of 32,000 tons, their length over all being 624 ft., and their beam 96 ft. They are to be of 20½ knots speed, and are to carry twelve 14-in. 50-calibre guns, twenty-two 5-in. 51-calibre rapid-firing guns, and a number of smaller weapons, including four 3-in. anti-aircraft guns and four submarine torpedo-tubes. The Secretary of the Navy says, however, that the proposals of the General Board, which are not divulged, involve a very material increase in the displacement, but as "to-morrow's developments abroad may require modifications of their characteristics, the Department feels it necessary to give this question most careful investigation and consideration."

In addition to these ten ships of the line there will be laid down six battle-cruisers—a type new to the American Navy. These vessels are estimated to cost each 3½ millions sterling. The proposal to add these ships to the Fleet is a direct result of the current war, and particularly of the performance of the ships of this class in the battle off the Falkland Islands, when the superior speed gave them "much strategic value, in that it enabled them to reach with great promptness their field of action." The performance also of this type of ship in the engagement in the North Sea, when the Blücher was sunk, has also impressed the Americans. The Secretary of the Navy points out that "when the battle-cruiser type was first brought out, it was argued that it could lie in the line with battleships, and be used as a battleship upon occasion. The experience of the war, however, seems to indicate that their primary function will be in independent action, and that if a possible antagonist is possessed of any material number of vessels whose speed enables them certainly to elude the battleship, and which are so powerful that they need not apprehend torpedo craft, it is necessary to have the battle-cruiser to cope with them." Admiral Dewey also points out that the battle-cruiser, in scouting operations, can penetrate the protective screen of the enemy and guard its own battleships or other craft from surprise attack. Admiral Dewey, however, sounds a warning note without adducing any support—"the particular course of the present war does not justify the prevalent exaggerated idea of their importance"—but, nevertheless, he and his Board have recommended the building of six of them, two of which are to be laid down in the ensuing year. In addition, there are to be ten scouts, each costing 100,000*l.* These, along with the battle-cruisers, are to obviate surprise attacks on the coast of the United States by seeking and maintaining contact with the enemy. In this connection, Admiral Dewey condemns the tendency of the country to place too much reliance on localised defences, such as fortifications, mines, and submarines. As regards destroyers, the new programme provides for fifty, at an average cost of 272,000*l.* each.

The submarine question naturally interests everybody connected with naval development, and it must be accepted that the naval advisers of the United States have taken a sane view. Admiral Dewey states that the deeds of the submarines have been so spectacular that, in default of engagement between the main fleets, undue weight has been attached to them. Their importance is less than the public believes. In the North Sea and in the Mediterranean they scored heavily on their first appearance, owing to surprise, and not to "inherent combatant superiority." "As," at present, "the Allies have learnt in great measure how to protect their commerce, as they learnt a few months previously to protect their navies from the submarine menace, it is apparent that the submarine is not an instrument fitted to dominate naval warfare. "The submarine is a most useful auxiliary, whose importance will no doubt increase, but at present there is no evidence that it will become supreme." Admiral Dewey's General Board recommended that in the five years' programme there should be included nine fleet submarines, each costing 300,000*l.*, and fifty coast submarines, each costing 130,000*l.* The Secretary of the Navy, however, while accepting the proposals regarding the larger fighting ships, has recommended fifteen fleet submarines and eighty-five coast submarines, although at the same time he makes the remark that a few months ago "a large majority of the people would doubtless have voted to go into the building of submarines on a scale so large as to leave little money for other fighting craft."

Greater importance is attached now than heretofore to auxiliary ships of the Fleet, and the five years' programme includes four gun-boats, one hospital ship, two ammunition ships, two fuel-oil ships, and one repair ship; while on aviation it is proposed to spend in the forthcoming year 400,000*l.*—double the amount voted for the current year; and on reserves of ammunition—as to the vital need of which the Secretary of the Navy expresses very strong opinions—it is proposed to spend 1,600,000*l.*, and to continue thereafter spending at the rate of 1,000,000*l.* per annum. Thus, in the next five years there is to be spent on new construction in the Navy a total of practically 100,000,000*l.*, fairly evenly distributed throughout the years. This is much greater than in recent years. It includes, for the next two years, money required to complete the ships already begun. Contemporaneously, there is to be a considerable increase in the *personnel*, so that the estimate for the coming year is over 42½ millions sterling, a very substantial increase on the estimates of any preceding year. Oil-fields for the supply of the Navy are to be purchased.

In many other directions the lessons of the war have been brought home to the United States naval authorities. There has been created a Chief of Naval Operations, and under him a definite scheme has been evolved to ensure preparedness. There has been reorganised in all respects the Secretary's Advisory Council, including all the technical officers and the heads of various departments, with a legal status and a responsibility to Congress. The Secretary also recommends that officers should be promoted for merit, and not by seniority, a proposal which scarcely needs any comment or commendation. Mr. Daniels, however, puts forward a somewhat novel system of nomination for promotion. On the plea that the Navy as a whole knows the best officers in the various grades, he suggests that the system of promotion should be based practically upon the vote of the officers senior to the grade under consideration. An officer, he contends, so selected would certainly possess such comparative merit that, from the point of view of naval efficiency, no mistake could possibly be made in nominating him for promotion. The result would be threefold: an ever-present personal stimulus for professional efficiency on the part of every individual officer throughout his career; utilisation of every officer who is physically competent to perform any of the various duties required of naval officers so long as they remain competent to do so; and the promotion of the officers specially adapted for command and flag ranks when they are in the prime of their vitality and ability, and with sufficient years yet ahead to enable them to perfect themselves in the vastly responsible duties that go with those grades.

CAPILLARITY AND SOAP FILMS.

THE Friday evening discourses of the Royal Institution have, for the present, been changed into afternoon discourses, and thus both the lectures and the discourses are now held in the afternoon, the lectures commencing at 3, the discourses at 5.30. So far as can be judged from the attendance at the first discourse, delivered last Friday, January 21, the selection of the hour meets the conditions.

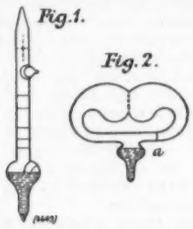
For many years past Sir James Dewar, F.R.S., has opened the discourse season, and he did so again last Friday, by making a further communication on "Problems in Capillarity," on which he discoursed a year ago. He had then spoken, Sir James told his audience, of the diffusion of gases through very thin membranes of rubber, and had studied the diffusion of gases not only into a vacuum, but also at higher pressures (up to 20 atmospheres) and at temperatures ranging from −40 deg. up to 40 deg. Cent. on the curves he exhibited. The curves exhibited showed that the rate of diffusion, measured in cubic centimetres per day per square centimetre of membrane, increased in all cases, and strikingly above 0 deg. Cent., as the temperature rose, the order of increase for different gases being: carbon monoxide, air, helium, oxygen, hydrogen and carbon dioxide; the latter two gases diffused much more rapidly, especially at higher temperatures, than the other gases. When the ratios were plotted logarithmically, all the lines showed breaks at 0 deg. Cent.; Sir James did not comment on this peculiarity, nor on the peculiar order of the gases. The very sensitive manometer used in those experiments was a U-tube, partly filled with oil, in which a vacuum was maintained in both limbs, and any water-vapour likely to be introduced, together with the gas, into the apparatus was condensed by charcoal and liquid air. The continuation of the inquiry into the properties of thin films and into capillarity, the lecturer remarked, was an appropriate subject for the Royal Institution; for it had been the last subject that had occupied Faraday. Sir James himself had felt the need of much thinner films than his rubber membranes, which had a thickness of 0.01 mm. or 0.02 mm., and he had hence turned his attention to soap films. As the discourse chiefly dealt with soap films, we have ventured to add these words to the title of our article.

Soap films, Sir James continued, and especially the thinnest "black" soap films, were considered exceedingly delicate, and the question arose whether they were intrinsically unstable or whether they merely collapsed because they were disturbed or were contaminated by the liquid or the air. It was certainly quite easy to keep a black soap film for months. Sir James put a closed glass jar, about 9 in. in diameter, on the lecture-table; near the bottom of the jar a black film formed a perfect horizontal partition. The term "black" must not be misunderstood; the film was perfectly transparent, and therefore practically invisible, but appeared black in reflected light. Plateau [of Brussels, who did such wonderful work on soap bubbles, even when blind] had estimated the thickness of the black film at 120×10^{-6} mm.; Reinold and Rücker had come down to 40 and 12 of the same units, millionths of a millimetre, Johonnot to 5, Rayleigh and Devaux (by different methods with different films) to 1.13 and to 2 or 3; Sir James's horizontal film, just mentioned, was not more than one-millionth of a millimetre in thickness. Yet the jar was not treated with any care, and Sir James demonstrated that the black film, if properly made in pure air or in a vacuum, was not at all unstable. He showed one film forming an equatorial plane in a sphere, and this would bear being shaken; the film moved within the sphere, always reassuming its equatorial position of equilibrium, horizontal or vertical; this film was not even quite black, but appeared slightly coloured. Then a vertical film was projected on to the screen; the upper, thinnest part [the lower part in the inverted image seen] was black, the black was very slowly spreading downward, as the liquid drained that way, and the whole film would have become black in a couple of hours; yet the parts of the liquid which were streaming down through the black portion and the coloured bands underneath it, did not destroy the film. Another sphere, showing a film, half black and half coloured, was rocked to and fro, together with a scale on which the advance of the black portion could be measured, the demarcation line being quite sharp; that line always tended to keep horizontal, while the sphere was being tilted. This stability of films, Sir James had discovered, was, moreover, known a hundred years ago; a Dr. Read, of Edinburgh, had, at the time when Wollaston described his cryophorus, put a small phial containing soap solution in a can of boiling water, closed the phial, and had "thrown" a bubble, which he had been able to keep for a long time. This "throwing" of a bubble or film by shaking the bottle, Sir James showed, required a knack. His bottles resembled thermometer tubes; wide but rather short, and contained soap solution in the bulbs; this solution was first put into the tube, which was then exhausted and sealed. When the bulb was heated (by the hand), a bubble or curved film was seen to start, say, from the right, travel over to the left, and then rise as a horizontal film (Fig. 1, overleaf); the next moment a bubble would start from the left and travel over to the right; some of the tubes exhibited contained more than a dozen horizontal films. One of the tubes exhibited had a conical side pocket; a film travelling past that opening would partly enter it, and when the pocket was warmed externally by the hand, a bubble would be seen to swell out from the open-

ing, reach over to the other glass wall, and then split into two horizontal films. The diagram, Fig. 1, very crudely indicates the beautiful phenomena; the dotted lines in the upper part of the diagram mark the position of loops of wire, fixed in horizontal or vertical planes, as will be described lower down. In some of the tubes exhibited the films looked slightly convex or concave; they travelled up and down the tube under temporary illumination by the lantern beam. Those multiple films were easily produced, Sir James showed, by violently shaking the tubes so that they were all full of froth; the films would afterwards make their appearance as

Fig. 1.

Fig. 2.



the froth liquefied; it was essential that the tubes should be highly evacuated, so that a click could be heard when the shaken liquid struck the other end of a tube.

As these tubes were not convenient for some measurements, however, Sir James devised another form of apparatus. These were Y tubes, the two upper open ends of which were so bent and blown out into spherical cups that the rims touched one another. Thus a closed vessel was obtained, which was hermetically sealed after putting in some soap solution and evacuating, the shape being somewhat as in Fig. 2. The main soap film would form across the stricture where the two cups were fused together (indicated by the dotted line of Fig. 2). But smaller films would also form in the narrower parts of the tubes, and such a film (at *a*) would act like a stop-cock; to remove such a stop-cock, that part of the tube was heated or cooled from outside, by a piece of glowing wire or coal or by liquid air. The whole vessel fitted into a wooden box, black inside, and could be illuminated within the box by a small electric torch placed in a pocket of the box. With the aid of this apparatus the stability of the films above-mentioned could further be demonstrated, and the rate of advance of the black portion could be measured. One of the rectangular vertical films exhibited showed (directly observed, not projected) quite sharply four blacks (or a first black and three grey bands, immediately following one another, without transition tints, in horizontal stripes), a white, and finally a yellow portion. When the tube was tilted so that the liquid washed over the film which was being kept in a vertical plane, irregular streams were seen to run down the film; but the film cleared quickly, and in two minutes nearly the whole film appeared uniformly black of the first order; immediately underneath the black followed a series of narrow coloured horizontal lines, and finally a silvery portion. This beautiful film had a length of more than 2 in.

The measurements on the rate of fall (advance) of the black line were also made with the straight tubes mentioned, into the upper portions of which circular or rectangular loops of platinum wire were inserted in various positions. Thus the films might be horizontal or vertical, and the rectangles supporting them might have their long or their short sides vertical. These remarks will explain the following table on the "Rate of Fall of Black Line in Millimetres per Minute:"—

Circle	Film vertical in air	0.24 to 0.16
	Film vertical in vacuum ...	0.20 ,, 0.5
	Film vertical in vacuum on wire	0.33 ,, 0.16
Film horizontal in air		0.12
Film horizontal in vacuum		0.09
Rectangle, long side vertical ...		4 to 0.4
Rectangle, short side vertical ...		0.2 ,, 0.016

Another table exhibited, to which the lecturer did not have time to refer, however, showed that the surface tensions in the coloured and the black films varied very little in magnitude; expressed in milligrammes per centimetre, these surface tensions ranged from 26.5 in a colourless film to 26.3 in a slightly coloured film, to 26.1 in a film 5 per cent. of the area of which showed the first black, and to 25.9 in a film showing the second black all over.

Sir J. Dewar then alluded to other means of producing films; for example, by dropping oil on clean water. An American physicist had recently taken collodion solution instead of oil, and obtained thereby films 7×10^{-6} mm. in thickness. Those films shrivelled up and cracked near their edges as the solvent (amyl ether) evaporated, and the dry blackish film could be lifted off with the aid of a platinum-wire loop; such a film afterwards looked black if consisting of one thickness only, or silvery white if partly folded over.

In concluding, the lecturer pointed out that such researches were not by any means so far removed from practical value as might appear. Utilisation of the peculiarities of surface tension had, at the Broken Hill mines in Australia, rendered possible the separation of the intimately mixed sulphides of zinc and lead from the complex silicates accompanying them. When the crushed ore was stirred with plenty of water, no separation took place by gravitation. When a few drops of oil or of oleic acid were then added to the pulp mixture, and the mixture was violently shaken into a froth [various means are used for this purpose in practice], the sulphide particles were lifted up to the top [probably by the air bubbles adhering to the greasy particles], whilst the silicates settled at the bottom. Thus an industrially very important separation by "oil flotation" had been worked out at Broken Hill.

Mr. W. J. Green, B.A., and Mr. J. W. Heath, F.C.S., assistants at the Royal Institution, were in charge of the demonstrations.

NOTES.

The Work of the British Merchant Navy in War Time.

Some interesting data were given on this subject by Mr. W. S. Abell, M. Eng., Chief Ship-Surveyor of Lloyd's Register, in the course of the James Watt lecture, delivered, on the 21st inst., before the Greenock Philosophical Society. Mr. Abell estimated that there were normally engaged in the foreign overseas trade 3600 vessels exceeding 1000 tons measurement, of which one-third was liners on regular routes carrying passengers or merchandise, and averaging 5800 tons gross, while two-thirds were tramp steamers, averaging 4000 tons. Approximately 800 had been requisitioned by the Admiralty for the purpose of supply and for transportation of army units, forty-two had been detained in enemy ports, and seventy-eight in neutral or allied ports in the Black and Baltic Seas. The result of enemy attack during the first year of war was the destruction of 139 steamers useful for ocean-going purposes. The total number of steamers thus deducted is, roughly, 1050, but there were added 100 captured and interned German vessels, so that the net reduction was 950, equal to about 25 per cent. The effect of the war had also been to draw heavily, for naval purposes, upon the *personnel* of the merchant marine, and the rate of reduction was probably equal to that in respect of tonnage. Ships, however, now carried heavier cargoes, owing to the replacement of passenger steamers in ordinary liner traffic by large general traders, the utilisation of the steerage of passenger liners for cargo purposes, and by fuller loading, due to time being allowed for the collection of cargo, since less importance was attached to regular dates of sailing. Notwithstanding the reduction of 25 per cent. in the number of vessels engaged in oversea trade, the reduction in the number of men (to about the same extent), and the falling off in the average number of voyages per ship per annum from 4½ to nearly 3, since supplies had to be taken from more distant countries, the weight of the merchandise imported was only reduced by about 12 per cent., the weight of the cargo carried for each 100 tons net of shipping having increased from 115 tons weight to nearly 145 tons weight. As regards loss of shipping, this was very much less than in previous great wars. The Royal Commission on Food Supply in Time of War estimated in 1905, from somewhat meagre data, that the premiums for war risks should be taken at 5 per cent. on shipping values and 1 per cent. on property values. These rates were fixed by the State under the war-risk scheme for the present year, 90 per cent. of the loss being borne by the country, and the balance by the ordinary insurance associations. The experience of the first six months of the war had indicated that that empirical value approximated very closely to the truth. Out of 4400 steamships entered in the war-risk associations, 172 were lost by the perils of war. The shipping value lost was 6¼ millions sterling, out of about 150 millions sterling, whilst the property losses came to 7¼ millions sterling out of a total value of cargo of about 1500 millions sterling. The losses in value among entered ships for the first year of war were thus about 4 per cent. per annum, and for property about one-half of 1 per cent. per annum. Quoting the late Admiral Mahan, who regarded commerce destruction as only an important secondary operation of naval war, Mr. Abell was able to show that that distinguished American naval writer had once more proved correct when he pointed out that while commerce destruction might cause embarrassment and distress, it could not be regarded as a primary measure sufficient in itself to crush an enemy, especially when the nation against whom it was directed possessed, as Britain did, the two requisites of a strong sea-power and widespread commercial and powerful fighting navies. Commerce-raiding by our enemies' cruisers was practically broken after the first three months of the war, as was clearly established by the details carefully collected in Mr. Abell's very interesting lecture.

Radium from Carnotite.

In discussing the constancy of the radium-uranium ratio quite recently, on page 38 of our issue of January 14, we mentioned that carnotite was the chief radium ore of the United States. A further Bulletin of the United States Bureau of Mines (No. 104) deals with the isolation of radium from this ore, as carried out by Charles L. Parsons, R. B. Moore, S. C. Lind, and O. C. Schaefer, in Long Park, Colorado, on behalf of the National Radium Institute and the Bureau of Mines, which own mines there. The plant was built in 1914, and operations were started in June of that year; the preliminary runs were so successful that a second, larger plant was opened in February, 1915, and both these plants are kept running. Carnotite is a hydrated vanadate of uranium and potassium, containing, in addition to barium, with which radium is generally associated, iron, aluminium, lead, and silica. The ore is less complex than the carnotite of Southern Australia, which occurs, together with ilmenite, a titanium-iron oxide; the treatment of the two carnotite ores is hence quite different. To isolate the traces of radium from tons of ores, the ores are leached with acid or with alkali, or both, or they are fused with sodium sulphate (salt cake) or sodium carbonate. The former fusion method, originally applied to pitchblende, is also used by S. Radcliffe in Australia (see ENGINEERING, vol. xcviii., page 691, December 11, 1914); otherwise acid leaching is now preferred; fusion with sodium carbonate has the disadvantage of bringing large amounts of silica into the solutions. The Bureau of Mines adopted leaching with hot, strong nitric acid; this acid will dissolve the radium-barium sulphates, which are not soluble in weak acids, though the use of strong, hot acids involves considerable difficulties. To reduce the expense, the acid is recovered on the spot from the sodium nitrate into which it is converted by the treatment. The pulverised carnotite is gradually fed into earthenware bottles containing boiling nitric acid of 38 per cent. The solution (containing nearly all the radium and uranium, but only 50 per cent. of the vanadium) is sucked through earthenware filters; the solid residue is discarded. The solution is nearly, but not completely, neutralised with caustic soda, care being taken not to precipitate any iron and vanadium, and, not yet, any radium, which ought to fall out afterwards, when barium chloride and sulphuric acid are further added to the still acid solution, as radium-barium sulphates. Thus a precipitate of sulphates is gained which settles for four days in conical tanks, and is then separated through earthenware filters from the solution, from which uranium and vanadium are subsequently recovered. The kilogramme of sulphates contains about 1 milligramme of radium in an insoluble form. The sulphates are mixed with one-fifth their weight of pure charcoal and heated in graphite crucibles to 800 deg. Cent., to reduce the sulphate to sulphide; the sulphide is dissolved in hydrochloric acid, with the generation of hydrogen sulphide, which sometimes catches fire [owing probably to the presence of phosphorus-hydrogen compounds], and the solution of almost pure radium-barium chlorides is fractionated in strong, hot hydrochloric acid; the

silica-lined vessels of the Rogeat Company, of Lyons, France, have answered for this purpose. The fractionation is carried on in a series of five steam-jacketed kettles of 250 litres capacity, the circulation being such that the crystallised salt and the liquor move in opposite directions. The liquid has several times to be filtered and treated with ammonium sulphide to remove traces of barium sulphate and lead salts. Subsequently the radium is precipitated, still together with the barium, by sodium carbonate; the precipitate is dissolved in pure hydrobromic acid, and by some twelve fractionations these two metals are finally separated, the resulting radium bromide being of 60 to 80 per cent. purity. About 90 per cent. of the radium in the ore is gained. As regards the uranium, the recovery is also very satisfactory—up to 94 per cent.; but the yield of vanadium is only 30 per cent.; this is the weak point of the process. The chief product is, of course, the radium, and of this 4285 milligrammes had been produced up to August, 1915—*i.e.*, in the first months including the experimental period—at a total cost of 37,599 dols. per gramme, from 724 tons of ore, which yielded in addition 31,650 lb. of uranium oxide and 11,528 lb. of vanadium oxide. The values of these latter products are not stated; but the prices of chemicals are no more normal in the United States now than they are elsewhere.

LITERATURE.

The Limitations of Science. By LOUIS TRENCHARD MORE, Ph.D., Professor in the University of Cincinnati. London: Constable and Co., Limited. [Price 6s. 6d. net.]

THIS book consists of a collection of articles that, having already appeared in such periodicals as the *Hibbert Journal*, the *Monist*, &c., have now been corrected and enlarged by the author, in the hope that, viewed collectively, they may be the more effective in emphasising the difference between the domain of physical investigation and that of metaphysical deduction. The contention is that natural phenomena and laws are independent of our thought, and must be examined objectively or verified by experimental test. We could have subscribed the more cordially to this thesis if the author had defined with some precision what he meant by a "law of Nature," but this has not been done, and we wander rather uncertainly among laws, theories, and hypotheses. He does suggest that the term "hypothesis" should be confined to those speculations in which we indulge when we attempt to define the causes of phenomena, and the word "law" to those generalisations which are based on experimental observation of a material world. The misfortune is that philosophers and physicists are not agreed where the material world ends, and the definition here suggested does not advance us beyond the point of saying that a "law" is equivalent to the accumulated records of man's experience; but we doubt if the author would accept this construction. On the other hand, it might be doubted if in physics the term "law of Nature" has any precise meaning. All the so-called laws of nature on examination are reduced to man's hypotheses about Nature, and these vary with every accretion of knowledge. The "laws of Nature" seems to be essentially a metaphysical phrase, in which we decorate and try to give stability to our guesses at nature's mechanism and operations.

But where mechanism is studied and encouraged for forwarding material interests, where the objects discussed and handled appeal to us as real objects, possessing the sensible properties of occupying space and resisting change of motion, the author's impatience at some of the views recently put forward by scientists concerning matter and energy, ether and electricity, will meet with a good deal of sympathy. Practical results are not promoted by asserting that electricity is a static strain or a vortex ring; that matter is a hole in the ether, and similar expressions by which distinguished physicists have endeavoured to translate mathematical conclusions into ordinary language. Lest this should be thought to be an unworthy view to take of transcendental research, we hasten to add that the author would not limit physical investigation in any direction. His unsparing criticism is directed against those who would allow the vain speculations of metaphysics to masquerade in the sober guise of experimental inquiry. His book, in correcting the unintelligent readiness with which some minds receive all that is bizarre and extravagant, is useful, but he has missed the opportunity of a calm, deliberately-reasoned criticism that would have furnished a valuable mental exercise to those who are intelligently interested. It is not to be expected that the author would propose any alternative explanation of the facts revealed by the experiments of Thomson, Rutherford, Bragg and others, even if he accepts the results as facts; but he might have spared us his cheap sneers at certain eminent scientists, such as Sir Oliver Lodge, "who bestows on the ether the ability to carry ghostly messages as well as light."

Undeterred by want of success in the past, the human mind will ever seek to penetrate the causes of natural phenomena. It is hopeless to attempt to exclude reasoning as beyond the scientific purview. The author praises Newton for refraining from publishing how the forces of attraction could act through space, but Newton's silence on this point did not prevent speculation, nor did he abandon the idea that matter could not act where it was not. He never accepted the theory that gravity could be innate, inherent, and essential to matter, an explanation that might satisfy some minds, and where we presume the author would advise us to leave it. The difficulty that presented itself to Newton, of action at a distance, is one that has been felt by many philosophers since, who, guided by experiments in other departments of physics, have constructed an elaborate mechanism for its elucidation. Much of the unsatisfactory character of the scaffolding erected is due to the fact, as the author points out, that it is necessary to assign to hypothetical quantities, as the luminiferous ether and ions, the properties and attributes with which ponderable matter has made us familiar. The limitations of our senses prevents us recognising or imagining new or other properties.

The chapter on Descartes and the description of the system of vortices, that was so generally accepted as satisfactory by the philosophers of his day, should prove valuable both in supplying information and in correcting errors. Descartes is one of the few whose reputation has been resuscitated after eclipse, and a tendency may be detected in some quarters to replace him on even a higher pedestal than he formerly occupied; but few know what to admire and what to distrust in his teaching. He owed his authoritative position not a little to the use of a hypothesis that did not violate the philosophic principle that matter cannot act where it is not. That other difficulties, unforeseen and unexplained, remained, goes without saying, and as a mechanical system it is hard to see that his system possessed any great merit over the old devices of cycles and epicycles that it displaced. Descartes rendered valuable service to philosophic science, and he deserves to be honourably remembered here. We are sorry that the author cannot bury him without indulging in a sneer at the expense of those modern philosophers "who think any hypothesis valuable that escapes contemporaneous troubles."

In succeeding chapters Professor More describes the position at which scientific investigation has arrived, and discusses the consequences of several hypotheses that now find energetic support. But it is in the last chapter that he delivers his most telling attack against what may be held to be a real danger to society. If the deductions from metaphysical hypotheses are regarded as established and unquestioned truths, ethical teaching will be injured and the formation of character weakened. Such a result, it would seem, must follow if we trust too confidently to science as the sovereign of all knowledge, and accept the principle that all phenomena relating to life are to be attributed to the action of physical and chemical processes only. Some of us are not prepared to regard our ideas of morality and religion, of conduct and intelligence, as explicable simply in terms of positive and negative electrons, the ether, and similar vague metaphysical creations. We are at one with the author in considering these speculations as outside the domain of science, and regard his pungent strictures as justified. Perhaps he is travelling somewhat out of the record in discussing the aims and methods of eugenists, who are groping their way to the scientific treatment of a difficult problem. The author's cautions and criticisms are generally effective, and he will have the support of those who preserve their old-fashioned notions of ethics and life.

SHELLS; MORE SHELLS.

TO THE EDITOR OF ENGINEERING.

SIR,—Your correspondents signing "A. C." and "Index" appear to be absolutely at sea about the process and mixture referred to by me in ENGINEERING of the 17th ult., as doubtless others more competent than I am in such technical details will tell these gentlemen in due time if they think this necessary. Personally I prefer to take no notice of hyper-critics who choose to make personal attacks under cover of *noms de plume*.

As regards the remarks of Mr. E. Wheeler and Mr. Frederick Mann, I would call their attention to a remarkable address on the best material and mixtures for shell bodies given by Dr. J. E. Stead, F.R.S., before the Cleveland Institute of Engineers on the 16th ult., in which occur the following words:—

"The only question is, and we are justified in asking it, whether they (the authorities) are certain as to what is suitable and what unsuitable material. It must be obvious that it is only by mechanical testing that one can find out. As the question can so easily be settled by making suitable mechanical tests on finished shells, such as I myself have made with convincing result in material at present barred, is it not in the national interest that such tests should be made by the authorities at head-quarters? If the results of my mechanical tests are confirmed, then the obvious thing to do is to alter the specifications forthwith. If the mechanical tests are found to be conclusive, then it would be a national crime to reject material on any chemical specification before submitting the steel in question in the form of a finished shell to the more convincing mechanical test."

This warning by a noted metallurgist naturally refers to steel, but it is equally applicable to cast (iron) and other metals suitable for shell bodies.

In the same report a description by a writer of the German shell fragments found at West Hartlepool, Whitby and Scarborough—which description is also applicable to the German shell fragments in my possession and sent me from the battlefield—reads:—

"One can have little conception of the terrible nature of these until they are handled. They bristle all over with horrible points and edges—some as keen as a razor. One peculiarity is the manner in which the fragments broke, leaving what may be described as 'sheer fractured surfaces' with sharp, knife-like terminations. The tracks of the fractures were often at angles of 35 deg. to 45 deg. to tangents of the shells, and the broken surfaces of many of them had a somewhat fibrous appearance, characteristic of great toughness. Tests made on the fragments of both the coarsely granular and fibrous varieties confirmed the conclusion that the former were brittle and the latter extremely tough."

As explained in my letter in ENGINEERING of the 17th ult., these same characteristics were observable in the breaking up in my presence of the annealed shell-body made from the special cast mixture in the Midlands. As a matter of fact, the metal of the said shell-body, presumably because of the process, the mixture, and manner of casting, appeared to be softer outside and closer and tougher inwards, which, I should say, ought to be ideal for the purpose.

It has been kindly suggested to me that I may be "flogging a dead horse" in thus trying to show how the mass of engineers and founders in this country might (in answer to Mr. Lloyd George's urgent appeal) help the Government in furnishing cast shell-bodies in addition to forged-steel ones at their command; and possibly this may be so, only, to use a similar metaphor, it may yet be equally conceivable that the alleged "dead horse" may perhaps be "flogged to life" again.

As regards the Germans using cast shell-bodies as well as forged-steel ones, it is common knowledge that cast shells, as well as fragments of cast shells, were found on the North-East Coast of England after the bombardment, and all of the high-explosive type, thus, as Dr. Stead in the same address has said:—

"Seeing that the Germans have devoted more time and money and thought to the preparation for this war than any other people, we must admit they know what they are doing, at least as well as we do."

Hence, as has been said before during this controversy, what is found to be good for the Germans in this respect ought to be equally good for us.

Mr. Wheeler writes that while suitable steel is obtainable, he sees no advantages in changing; we have also been assured that there is no lack of shell-bodies, and that it is explosives we are short of.

The obvious and pertinent replies to which are:—

1. Supposing an inexhaustible supply of suitable steel were obtainable, how is it to be worked into an inexhaustible supply of shell-bodies more than we are having now, seeing that special and expensive machinery is necessary, which is not available to the ordinary engineer and founder whom the Minister of Munitions so foolishly asked to help the Government, and work with, or use only, the "tools he had got"? Besides all this, and as you truly put it in one of your leaders lately, our general engineering and iron-founding industry "must be kept going," and how is this to be done if only the steel industry is to be exploited by the powers that be?

The Munitions Department have been officially asked "to seek fresh sources of supply by utilising the untapped engineering reserves of the country;" and how is this to be done without bringing into the services of the Government all the iron-foundries available for helping (as is done in Germany) in the making of cast shell-bodies with the simple machinery these foundries have got, in order to fill up the gap, and not for the purpose of replacing the already good supply of forged-steel shells?

2. If, again, we have such an abundant supply of shell-bodies, how comes it that Mr. Lloyd George went purposely down to Glasgow on Christmas Day to talk to

the engineers (not the chemists) and urged them to increase the supply of shell-bodies? We have also the Prime Minister—no later than on Friday last—appealing for, if not demanding, more shells, and still more shells, in his speech in the House of Commons. No word was mentioned of explosives.

In reply to Mr. Frederick Mann, I would say that so far he is quite right. I had something in reserve, and I could not very well write more than I did, for (amongst other reasons) the perfectly valid one he suggests. I can safely inform him, however, that the process and mixture having been protected, these were, I understand, freely offered by the inventor some considerable time ago to the British Government (gratis), only to meet with the usual delay or neglect. I believe, however, that only last week, on learning that the French authorities were taking considerable interest in the matter, an order has actually been placed by the British Ministry of Munitions for a number of shell bodies to be formed of the special cast mixture mentioned, so that it will be seen the cause appears to be progressing, and it is just possible that the suggested "dead horse" may after all before long be revivable.

As I have had occasion to state before, I may repeat that my interest in shell-body making is absolutely impersonal, my only personal interest being that I have a son at the front (with the Canadians), that my company has over 200 of its employees with the Colours, and that I am anxious that the general engineering and founding trade should have the opportunity of doing its fair share, and that thus our forces should at least be put on equal terms with those of the Germans in the matter of shells.

I have the honour to remain,

Yours faithfully,

JAMES KEITH,
Assoc. M. Inst. C.E., M.I. Mech. E., M.I. Mar. E.

Dunottar, Brondesbury, London, N.W.,
January 23, 1916.

TO THE EDITOR OF ENGINEERING.

SIR,—With further reference to my letter of the 4th inst., *re* "Shells; more Shells," I see from the letter of Mr. J. E. Hurst that my remarks *re* iron low in phosphorus are somewhat misconstrued. I am quite aware of the fact that an iron low in phosphorus need not of necessity be close-grained, but for the purpose, for which I advocate using the iron, the close-grained fracture would be the best. This closeness of grain I recommend securing by means of a low total carbon content.

I notice your correspondent "Index," in his epistle of January 10, remarks that tensile strengths up to the amount mentioned by Mr. Keith have been obtainable for many years with thin malleable castings, not more than $\frac{3}{8}$ in. thick. It might be interesting to this gentleman to learn that 33.6 tons tensile per sq. in. (or 27 tons on 1 in. area) have been obtained on test-bars of this thickness from a special malleable refined iron made exclusively at a Midland blast-furnace plant.

I commend this to your correspondents for their further consideration.

Yours faithfully,

FREDERICK MANN.

103, Albert-street, Wednesbury, January 24, 1916.

TO THE EDITOR OF ENGINEERING.

SIR,—In discussing "Shells; more Shells," I notice that "Index" refers your numerous readers to ten specific points with reference to cast-iron shells, but it is to be regretted that he lacks the main factors when discussing this important business—viz., modern science as applied to recent investigations in cast iron; therefore his discussion naturally does not enlighten us much on the subject either economically or scientifically. If "Index" will allow me to make a suggestion, I propose that he, or any of his friends conjointly with him, who may be interested in the economic conditions of shell bodies or any other material requiring like properties, will be good enough to deal with the matter scientifically; then I will, for my part, undertake to give them a good discussion on the matter.

All I ask is that they keep as near as possible to recent investigations, and to labour on ancient history as little as possible.

Yours truly,

W. J. FOSTER.

Darlaston Blast-Furnaces, Darlaston, January 24, 1916.

TO THE EDITOR OF ENGINEERING.

SIR,—Having followed with much interest the correspondence *re* cast-iron shells which has appeared of late in your columns, it would be interesting further to note that such an eminent authority as Dr. Stead has also been attacking the subject, but from a slightly different aspect.

He (Dr. Stead), in a paper read before the Cleveland Institute of Engineers, in which a number of analyses of German shells fired into England and elsewhere are collected, points out that by adhering to our strict analytical specifications we may unknowingly reject material which would otherwise be quite suitable for shells. The analysis of these shells given varies as follows:—C, 0.393 to 1.12 per cent.; Mn, 0.380 to 1.40; S, 0.027 to 0.083; and P, 0.028 to 0.105 per cent.; thus showing that the Germans do not stick to one strict specification. But, notwithstanding this wide variation of chemical analysis, and the use of steel containing a high percentage of injurious constituents, the specimens tested were all found to possess high tenacity, and, as Dr. Stead points out, did not burst in the gun, but in England and elsewhere. So as soon as the drastic restrictions are removed from our specifications, and our experts see the advisability of using either cast iron (as your correspondents recommend), or, as Dr. Stead suggests, any steel that gives a good tenacity, no matter what the chemical analysis is, the better it will be for the Allies as a whole.

Trusting I am not taking up too much of your valuable space,

I remain, yours truly,

E. J. DAVIS.

17, Chesnet-road, Plumstead, Woolwich,
January 24, 1916.

"BALANCING OF PETROL-MOTORS."

TO THE EDITOR OF ENGINEERING.

SIR,—I entirely agree with the conclusion arrived at by the writer of the article on "Balancing of Petrol-Motors" in your issue of the 21st inst.

The matter is one to which I have devoted considerable attention, and in "Internal-Combustion Engineering," of October 1, 1913, I drew attention to the magnitude of the "unnecessary" loads on petrol-engine crank-shaft bearings.

In the discussion on Mr. F. W. Lanchester's paper on "Engine-Balancing," at the Institution of Automobile Engineers, on March 11, 1914, I gave an abstract of some very complete calculations, which included the cylinder compression and explosion pressures plotted for several points in the revolution.

The engine was a large four-cylinder ($4\frac{3}{8}$-in. bore by 6-in. stroke), and (being a motor-lorry engine) had rather heavy pistons and connecting-rods. The crank-shaft was 2 in. in diameter and had three bearings.

I found that at 2000 revolutions per minute the *average* load on the centre bearing was 3880 lb., reaching a *maximum* of 5250 lb. when the inner cranks were turning the top dead centre just before one of the inner cylinders fired.

At this high speed the load on the centre bearing was but little affected by the cylinder pressures; the effect of the explosions was to reduce both maximum and average pressures.

By fitting balance-weights the average load on the centre bearing would be reduced to a little more than *one-third*, and the maximum lateral load to exactly *one-sixth*.

The ordinary split bearing is ill adapted for taking heavy loads in the plane of division; the more so as engine-fitters habitually "ease off" the side faces of the brasses as a safeguard against possible "nipping" of the shaft when tightening up the cap-bolts. Moreover, the lateral loads on the bottom bearing being reversed in direction at each revolution, tend to loosen the cap in the crank-case unless it is tightly fitted with a deep lip.

The intensity of the loads set up by unbalanced rotating masses is not so great in the case of the end bearings, but is still decidedly harmful, particularly as the deflection of the shaft causes a "bell-mouthing" effect.

In the course of the investigation I had a crank-shaft bedded into its bearings in the crank-case, and fitted with a double set of cantilevers acting on the crank-pins. These cantilevers were loaded by means of a heavy spring connecting their free ends, so as to impose loads on the shaft equal to those set up by centrifugal force at 2000 revolutions per minute.

The deflection of the crank-case in a lateral direction was measured and found to be no less than $\frac{1}{2500}$ in. at the centre, and the angular displacement of the ends of the shaft would be about $\frac{1}{1656}$ per inch run—enough to cause serious bell-mouthing of the brasses.

In conclusion, I would mention that the most successful racing-cars in the last two years have had balanced crank-shafts, *e.g.*, Maxwell, Stutz, Sunbeam, Minerva, Vauxhall, &c. Several touring-cars are now fitted with balance-weights, *e.g.*, Cole eight-cylinder, Fergus Hispano-Suiza.

I append a tabular summary of the calculations referred to.

$4\frac{3}{8}$-IN. BY 6-IN. FOUR-CYLINDER ENGINE.

	Shaft. Unbalanced.	Shaft. Balanced.
Loads on Centre Bearing at 1000 Revolutions per Minute.		
Maximum vertical load	1,600 lb.	2,100 lb.
" horizontal load	1,000 "	280 "
Average load	1,320 "	996 "
Maximum vertical bending moment	6,800 in.-lb.	2,280 in.-lb.
" horizontal "	5,600 "	None
Loads on Centre Bearing at 1413 Revolutions per Minute.		
Maximum vertical load	2,800 lb.	1,500 lb.
" horizontal load	1,750 "	320 "
Average load	2,020 "	1,053 "
Maximum vertical bending moment	13,600 in.-lb.	4,560 in.-lb.
" horizontal "	11,200 "	None
Loads on Centre Bearing at 2000 Revolutions per Minute.		
Maximum vertical load	5,250 lb.	2,300 lb.
" horizontal load	3,300 "	550 "
Average load	3,880 "	1,466 "
Maximum vertical bending moment	27,200 in.-lb.	9,120 in.-lb.
" horizontal "	22,400 "	None

Yours faithfully,

O. D. NORTH, B.Sc., A.M.I.A.E.

76, Elm Park Mansions, Park Walk, Chelsea, S.W.,
January 23, 1916.

WAR MEMORIALS.—Professor S. D. Adshead, M.A., F.R.I.B.A., will deliver, at University College, six public lectures on architecture and sculpture in relation to war memorials, illustrated with lantern-slides, on Wednesdays, at 5 30 p.m., beginning on January 26. Admission free.

NON-INFLAMMABLE TIMBER.—The Timber Fireproofing Company, Limited, Townmead-road, Fulham, S.W., have issued a pamphlet containing extracts from recent Board of Trade reports on railway accidents, dealing with the use of non-inflammable timber for the construction of passenger railway carriages.

ELECTRICAL RAILWAYS.*

By HENRY METCALF HOBART, M. Inst. C.E.

(*Continued from page 72.*)

THE NORFOLK AND WESTERN 11,000-VOLT RAILWAY.

THE Bluefield Division of the Norfolk and Western Railway comprises the 29 miles of main line from Vivian to Bluefield, in the State of West Virginia. Fig. 13, on page 71 *ante*, and Fig. 14, below, show the plan and profile of the road, which is double track, with the exception of the Elk Horn Tunnel, which is single track. Sidings, branches into the coal-workings, and yard-trackage bring the aggregate electrified length of single track up to 97 miles. It will be seen from the profile in Fig. 14 that the line has long grades, sometimes amounting to over 2 per cent. In the Elk Horn Tunnel the east-bound trains ascend a 1.5 per cent. grade In addressing the New York Railroad Club, on March 20, 1914, Mr. George Gibbs made the following interesting allusions to this undertaking:—

"I will take the case of the Norfolk and Western first. It is, perhaps, the heaviest electric-traction scheme proposed anywhere in the world as yet. The coal traffic of this railway is the important one, and originates in the Flat Top and Pocohontas fields, which lie on the west slope of the Allegheny Mountains; it is this section of the road we are electrifying—that is, the section between Bluefield on the east and Eckman on the west end, a distance of about 30 route-miles, or about 90 track-miles. Within this distance, and practically at the summit of the Alleghenies, is the Elk Horn Tunnel, about 4000 ft. long; it is a single-track tunnel, and constitutes the "neck of the bottle," limiting the capacity of the entire road. The alternatives to electrification to relieve congestion were either to double-track the tunnel or to build a relief line, both of which would cost a great deal of money and require years of time.

"It is found that electrification of the existing tracks would not only give the desired increase in capacity of the line, but would give it promptly, and would afford

Fig. 14.

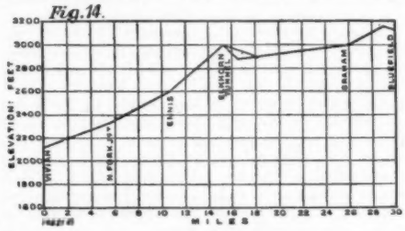


FIG. 14.—PROFILE OF ELECTRIFIED DIVISION OF THE NORFOLK AND WESTERN RAILWAY.

savings in operating costs which would carry the interest and depreciation charges on its cost and leave a handsome surplus besides. The maximum east-bound tonnage at present is about 65,000 tons per day up the gradient, of which about 48,000 tons is revenue traffic; this tonnage, by the way, is exclusive of the ordinary tonnage of the road—it is simply coal tonnage that I am talking about. This tonnage is loaded in about twenty train units of 3250 tons each trailing load. This train is hauled up a 2 per cent. grade over the mountain to Flat-Top Yard by three Mallet compound engines, thence to Bluefield, 15 miles further, over an undulating grade with 1¼ per cent. maximum by two Mallets. At this point trains are made up for the road run to tide water. The entire 30 miles that we are electrifying is what we might call a 'gathering division,' the tonnage being filled out in the section from the various coal workings; it is, therefore, treated as a separate engine division, and this makes the substitution of electric for steam power unusually advantageous and economical. For these Mallet engines we will substitute electric locomotives."

Electric operation of the Bluefield Division of the Norfolk and Western Railway was inaugurated in May of last year (1915) with twelve 240-British-ton locomotives of the split-phase type. This type of locomotive operates from a single-phase overhead conductor. In the case of the Norfolk and Western system, a pressure of 11,000 volts and a periodicity of 25 cycles per second are supplied from the overhead conductor.

Each 240-ton locomotive is made up of two 120-ton halves, and each half may be operated as an independent locomotive. The trains are, however, very heavy, and for grades of 1.5 per cent. or more, two 240-ton locomotives are necessary, the one at the head of the train and the other pushing at the rear. Trains of this composition, and comprising forty-five cars loaded with coal, weigh 2900 British tons, or, including the two 240-ton locomotives 3380 tons. They are known as "tonnage" trains. Such a train is made up at or near the west end of the division. The up-grade trip from Vivian to Ruth at the eastern end of the Elk Horn Tunnel is made at a speed of 14 miles per hour. Formerly it required three 240-ton Mallet engines—two at the head and one at the rear end of the train—to make the same trip at about 7 miles per hour, exclusive of stoppages for coal and water. Such a steam-locomotive train weighed complete $(2900 + 3 \times 240) = 3620$ tons, or 7 per cent. more than

* James Forrest Lecture, delivered before the Institution of Civil Engineers, on Tuesday, December 14, 1915. In the enforced absence of Mr. Hobart in America, this lecture was delivered on his behalf by Mr. John A. F. Aspinall, M. Inst. C.E.

the electric train. The total elevation from Vivian to Ruth is about 900 ft. The distance is 15 miles, the average grade thus being about 1.13 per cent.

On the assumption of the same pounds per ton of frictional resistance, the "drivers-to-draw-bar" efficiencies for these trains are—

$$\text{Electric train } \frac{2900}{3380} \times 100 = 86 \text{ per cent.}$$

$$\text{Steam train } \frac{2900}{3620} \times 100 = 80 \text{ per cent.}$$

The Norfolk and Western electrification provides the following important features :—

1. Decreased outlay for wages of locomotive crews and train crews due to the greater speed and longer trains.
2. Decreased outlay for maintenance of electric locomotives as compared with that of Mallets.
3. Greater annual train (and ton) mileage per locomotive.
4. Greatly increased capacity of the division.
5. Superiority of electric traction for lines with frequent and long tunnels.
6. Decreased outlay for track maintenance with electric locomotives as compared with Mallets.
7. Savings in brake-shoe renewals, and freedom from speed restrictions on down grades due to the heating of brake-shoes in virtue of employment of regenerative control.
8. Elimination of congestion at tunnels, especially at the single-track Elk Horn Tunnel.

It is desired to dwell for a moment on this last feature. The 3000-ft. single-tracked Elk Horn Tunnel is the bottleneck of the system. Even the inherently slow Mallets were driven through the tunnel at reduced speed to reduce the quantity of smoke and gases. It was necessary to delay sending in a train until sufficient time had elapsed partly to free the tunnel from the smoke and gases emitted by the preceding train. Such considerations occasion a bunching up of trains at both ends of a tunnel. Obviously, with steam trains, a serious congestion of this sort can only be slowly relieved owing to the time which must be allowed to elapse between the passage of successive trains. They cannot be "bunched" in the tunnel. With electric locomotives, very long trains can be taken through, headed by one 240-ton locomotive and with two more 240-ton pusher locomotives. A train of this formation may considerably exceed in useful weight any steam-hauled train, since each steam locomotive employed increases the amount of smoke and gases and the time required to put the tunnel in condition for another train. Electric trains maintaining a speed of 14 miles per hour can be despatched through the Elk Horn Tunnel at the rate of a train every 3 minutes, as against 6 miles per hour steam trains, of less useful weight, every 7 minutes. Taking into account the greater useful tonnage per train which can be carried electrically through the tunnel, and the greater speed, it may be fairly stated that any bunching up of tonnage on the division can be relieved by electric operation in about one-third the time which would be required with steam locomotives.

It has sometimes been claimed* that electric operation is inferior to steam-locomotive methods with respect to the ability with the latter to despatch trains in fleets in emergencies. It has been stated that in this respect electric operation takes away track capacity "just at the time when the operating official most needs it." While the author admits that such occasions may arise, he considers that for every such occasion there can be cited others where the electric operation of heavy freight-trains will permit of relieving, or (which is more important) preventing congestion by the increased capacity with which it endows a system with a given trackage.

Generating-Station at Bluestone.—For the case of the Norfolk and Western Railway, the single-phase electricity is provided from a special 25-cycle generating station located at Bluestone, as shown in Fig. 13. This generating-station is equipped with three 10,000-kilovolt-ampere steam-turbine-driven 11,000-volt single-phase generators. The pressure is stepped up from 11,000 volts to 44,000 volts, and transmitted at this pressure to five sub-stations, where are installed an aggregate of 28,000 kilovolt-amperes of transformers for stepping down to 11,000 volts, the pressure required at the locomotives.

* Mr. A. H. Babcock, at page 1851 of vol. xxxii. (1913) of the Transactions of the American Institute of Electrical Engineers, in a paper entitled "Mountain Railway Electrification," states : "A slight derangement of schedules, or an extra freight movement, citrus fruits or oil, or a blockade, for example, will cause congestion beyond any possibility of estimating. This traffic must be handled as circumstances require. It cannot be spaced conveniently for power demands, as many engineers and power men have suggested, but the terminal yards must be cleared as the cars accumulate."

At page 927 of vol. x. (1913) of *The Electric Journal*, in an article entitled "Heavy Electrification Tendencies," Mr. W. S. Murray writes : "Suppose a bunching up of trains and tonnage to take place at some point on the system, due to a wreck, a broken wire, a short-circuit, or trouble with signals. When conditions ahead have been adjusted and traffic may be resumed, the operating official in charge wishes to let his trains through, one behind the other, just as fast as his block sections will permit, and so make up time lost due to the breakdown. With steam service there is nothing to prevent this."

It has been shown that in such cases as that at the Elk Horn Tunnel there is, contrary to Mr. Murray's suggestion, much more to prevent the resumption of normal conditions with steam service than with electric service, and equivalent conditions are constantly met.

The Norfolk and Western Electric Locomotives.—The twelve 240-ton electric locomotives operating on the Norfolk and Western Railway are equipped with the split-phase system ; 25-cycle 11,000-volt single-phase electricity is collected from the overhead conductor by a pantograph trolley, with a sliding collector. This high-pressure electricity is received by a step-down transformer, carried on the locomotive, and indicated at A in the diagram in Fig. 15. The pressure at the secondary terminals of this transformer is 750 volts. Part of the electricity goes direct from the secondary of the transformer to the polyphase motors (indicated diagrammatically as B in Fig. 15) which drive the locomotive. The remainder of the electricity passes through the phase-splitter C, on its way to the polyphase motors B. By this means the single-phase electricity supplied to the locomotive is converted into polyphase electricity, and is thus made suitable for driving the polyphase motors B. Each 240-ton locomotive is equipped with eight of these polyphase driving-motors. The power from the motors is delivered to the driving-wheels through geared side-rods, the gear ratio being 4.72.

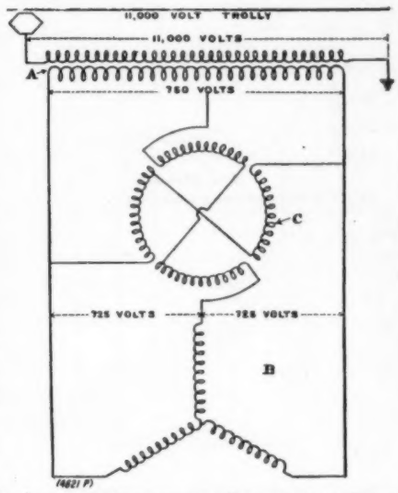


FIG. 15. CONNECTIONS OF TRANSFORMER PHASE-SPLITTER AND MOTOR OF NORFOLK AND WESTERN LOCOMOTIVE.

The rotors of the polyphase motors are provided with definite windings and slip-rings, so that water-rheostats may be inserted in the rotor-circuits during the starting and also for purposes of speed control.

The 240 British tons of weight of the Norfolk and Western locomotive is made up of 227,000 lb. of electrical equipment and 310,000 lb. of mechanical equipment. The motors can be operated with either eight or four poles. With the former connection the speed is 14 miles per hour, and the continuous rating is 2600 horse-power, corresponding to a traffic effort of 68,600 lb. With the four-pole connection, the speed is 28 miles per hour, and the continuous rating is 3000 horse-power, corresponding to a tractive effort of 40,000 lb. For these two connections the weight of the electrical equipment per horse-power of continuous rating works out respectively at 86 lb. and 75 lb.

When addressing the New York Railroad Club on March 19, 1915, Mr. George Gibbs gave the following data of these electric locomotives :—

Length over-all	105 ft. 8 in.
Rigid wheel-base	11 ft.
Truck wheel-base	16 ft. 6 in.
Diameter of driving-wheels	62 in.
Diameter of pony-wheels	30 ,,
Weight on drivers	197 British tons
Total weight of locomotive	240 ,, ,,

The Mallet locomotives which were employed on the Bluefield division prior to its electrification were described by Mr. Gibbs as "of the latest compound type, fitted with mechanical stokers and superheaters." He gave their weight as "about 370,000 lb. on drivers, and 540,000 lb. total, including tender, and are estimated to have a tractive power of about 85,000 lb." He stated that tonnage-trains were handled normally at a speed of from 7 to 8 miles per hour on the grades, except in the Elk Horn Tunnel.

(To be continued.)

EAST INDIAN RAILWAY.—The effective length of the East Indian Railway is 2447¾ miles, of which 0.85 mile is six-track, 3½ miles four-track, 24 miles three-track, 611 miles double-track, and 1808 miles single-track. In addition to these lines, the Delhi, Umballa and Kalka Railway, 191⅝ miles, and the South Behar Railway, 79½ miles, are worked by the East Indian Company, making the total length worked at the close of September last year, 2718½ miles. Satisfactory progress has been made with the construction of a relief line from Burdwan to Howrah, and it will probably be opened for traffic about the middle of 1916. The East Indian Company has no other new works of importance now in hand.

THE FLOW OF AIR THROUGH NOZZLES.*

By Captain THOMAS B. MORLEY, B.Sc., Associate Member, of the University of Glasgow.

Introduction.—The primary object of the experiments described in this paper is to compare various forms of nozzles, with regard to their effectiveness for the production of jets of air having as high a mean velocity as possible. This forms the subject of Section I. Incidentally, a comparison of the discharge and the velocity attained can be made with those calculated from the ordinary theory, in which reversible adiabatic expansion is assumed.

Section II. of the paper refers to an investigation into the nature of the impact produced by a jet upon a flat plate, and its relationship to the reaction of the jet.

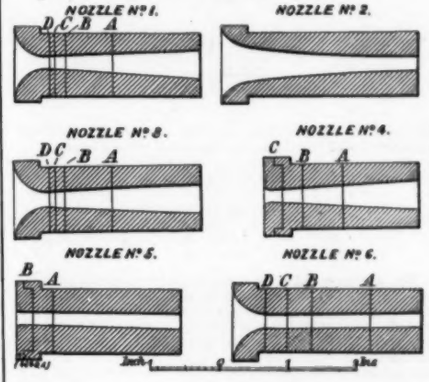
SECTION I.—EFFICIENCY OF NOZZLES.

The greater part of this section refers to experiments on nozzles only, but in view of the good results obtained with very short nozzles, two simple orifices were also tested. The results of the orifice experiments are stated separately.

Forms of Nozzles Tested.—Sections of the nozzles tested are shown in Fig. 1 (below). The nozzles were all made of gun-metal.

The features the influence of which was investigated were the entrance curves, the rate of divergence after the throat, and the length. The latter two together, of course, determine the ratio of the cross-sections at the outlet and at the throat. With the exception of nozzle

Fig. 1. NOZZLE FORMS.



No. 2, the nozzles were of the convergent-divergent type originally, and after being tested in this form were cut down to successively shorter lengths, as indicated in Fig. 1 and in Table I. (below).

TABLE I.—*Experimental Nozzles.*

Number (see Fig. 1).	Diameter at Throat.	Diameter at Outlet.	Length.	Approximate Taper = (Change of Diameter in .. Inches Length of Cone).
	in.	in.	in.	
1	0.1935	0.42	2.7	
1A		0.262	1.44	
1B		0.196	0.75	1 in 8
1C		0.1945	0.60	
1D		0.194	0.52	Nearly parallel.
2	0.192	0.192	2.85	—
3	0.195	0.42	2.75	
3A		0.32	1.43	
3B		0.23	0.75	Varying.
3C		0.207	0.60	
3D		0.205	0.53	
4	0.193	0.42	2.21	
4A		0.29	1.12	1 in 8
4B		0.213	0.55	
4C		0.196	0.28	
5	0.1955	0.23	2.4	
5A		0.205	1.12	1 in 64
5B		0.199	0.28	
6	0.196	0.23	2.75	
6A		0.219	2.00	
6B		0.216	1.16	1 in 64
6C		0.200	0.80	
6D		0.196	0.50	

Complete series of tests were carried out on most of the nozzles, but not on all. In some cases, when it became evident that a certain nozzle form would give results of an intermediate character—for example, that results for No. 1B would lie between those of Nos. 1A and 1C—only a limited number of experiments were made. On the other hand, in certain cases, a few experiments were made on nozzle forms intermediate to those shown.

Nozzle No. 3 had a curved contour after the throat instead of a straight conical divergence. Nozzles 1 and 4 had the same taper, but different entrance curves.

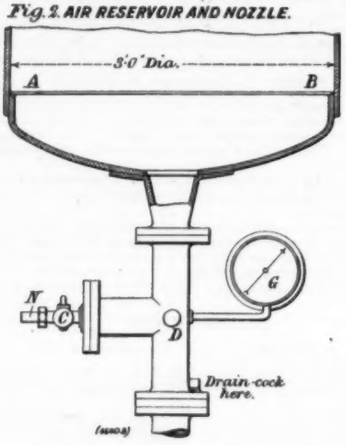
* Paper read before the Institution of Mechanical Engineers, January 21, 1916.

Nozzles 5 and 6 had a very gradual taper and different entrance curves. Nozzle 2 was convergent only, and had a very long entrance curve compared with the others.

Measurement of Discharge and Discharge Coefficient.—The method adopted for the measurement of the discharge consisted in determining the time-rate of change of pressure and of temperature in a large closed reservoir from which air was allowed to escape into the atmosphere through the nozzle under test. The theory of the method is as follows:—

Let v = volume of the reservoir, and let m, p, and T

Fig. 2. AIR RESERVOIR AND NOZZLE.



be the mass, the pressure, and the absolute temperature respectively of the air in the reservoir at any time t.

Then $m = \frac{p\,v}{R\,T}$ where R is a constant;

$\therefore$ the rate of discharge

$$\frac{d\,m}{d\,t} = \frac{v}{R\,T} \times \left(\frac{d\,p}{d\,t} - \frac{p}{T} \times \frac{d\,T}{d\,t}\right) \quad . \quad . \quad (1)$$

The air reservoir used was a cylindrical vessel of mild steel, 3 ft. in diameter and 6 ft. high, with domed ends. The lower part of the reservoir is shown in section in Fig. 2. The nozzle N was coupled to the cock C, which was screwed to the horizontal branch of a 3-in. T-piece bolted to the bottom of the air-vessel. Below the T-piece was a blind flange and a 3-in. cast-iron pipe acting as a standard to carry the weight of the reservoir. The total volume of air contained when all valves were shut was 46.9 cub. ft. The gauge G indicated the pressure in the reservoir.

In the first experiments a curve of pressure was obtained automatically by means of a recording pressure-gauge, but subsequently this was discarded, and more accurate results obtained by noting on a stop-watch the times at which the pointer of the gauge G just coincided with a particular series of pressure graduations. The gauge was frequently calibrated. The range of pressures in the experiments was from about 70 lb. to 25 lb. per sq. in. absolute.

The temperature in the reservoir was found in the earlier experiments by measuring the electrical resistance of fine bare copper wire stretched on a wooden frame placed horizontally at A B, which occupied nearly the whole of the cross-section of the reservoir. Arrangements were made to enable the resistance to be determined very rapidly, so that it could be found at intervals of a few seconds. In later experiments a small thermo-couple was inserted at the point D; the temperatures found by its aid practically agreed with the previous results.

Fig. 3 is typical of the results obtained. During the greater part of the time of flow—namely, from $p = 55$ lb. to $p = 22$ lb. per sq. in.—the range of temperature did not exceed 2 deg. Fahr. It was also found that during this period of nearly constant temperature log p was a linear function of the time t.

Curves of log p and t for several nozzles are shown in Fig. 4. It will be noticed that the only deviation from a straight line takes place at the earlier stages of the flow—that is, when the temperature is falling rapidly.*

Experiments in which the initial pressures differed widely produced graphs which became parallel—for a given nozzle—after the initial stages of the flow. Hence it was decided to take T as the mean temperature for that part of the flow during which the curves of Fig. 4 were straight, to regard T as constant, and to replace

* According to the usual theory, and provided that the ratio of the pressure of the atmosphere into which the jet issues, to the pressure in the reservoir, is less than the critical value 0.528, the rate of discharge is given by $\frac{d\,m}{d\,t} = k\,\frac{p\,A}{\sqrt{T}}$, where k is a constant, and A is the cross-section of the nozzle at the throat. Also, from equation (1), $\frac{d\,m}{d\,t} = \frac{v}{R\,T} \times \frac{d\,p}{d\,t}$ if T be constant, so that $\frac{d\,p}{d\,t}$ is then proportional to p, and hence log p is a linear function of t.

equation (1) by the equation:

$$\frac{d\,m}{d\,t} = \frac{v}{R\,T} \times \frac{d\,p}{d\,t} = \frac{v}{R\,T}\,b\,p \quad . \quad . \quad . \quad (2)$$

where b is the slope of the curve of log p and t.

The straightness of the curves of log p and t indicates that the actual discharge is proportional to the theoretical, or that the discharge coefficient is constant for the range of pressure concerned. So long as the pressure in the reservoir exceeds $\frac{\text{atmospheric pressure}}{0.528}$, say 28 lb. per

Fig. 3. RATE OF CHANGE OF PRESSURE AND TEMPERATURE.

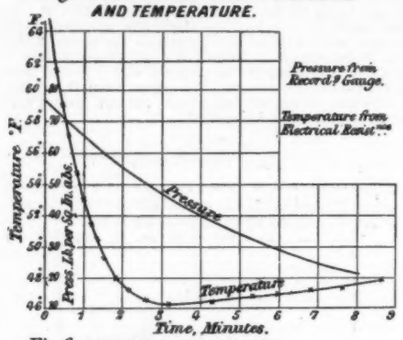


Fig. 4. LOG. PRESSURE AND TIME.

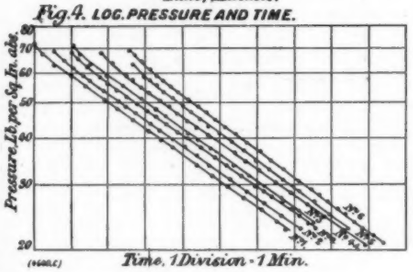
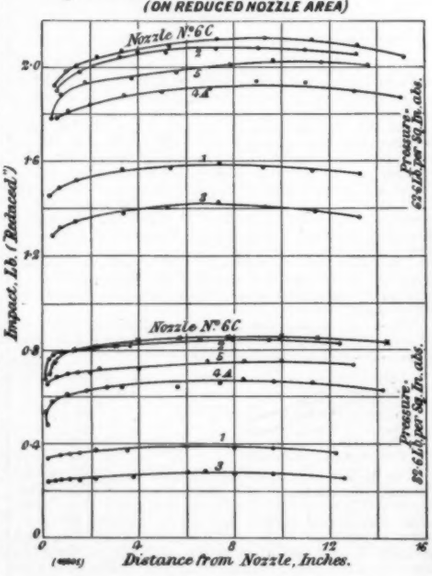


Fig. 7. IMPACT AT VARYING DISTANCES. (ON REDUCED NOZZLE AREA)


Nozzle N°6C
Nozzle N°6C
Impact, Lb. ("Reduced")
Pressure, 83·6 lb. per Sq. In. abs.
Pressure, 85·6 lb. per Sq. In. abs.
Distance from Nozzle, Inches.

sq. in. absolute, the discharge according to the usual theory is given by

$$\frac{d\,m}{d\,t} = 0.534\,\frac{p\,A}{\sqrt{T}},$$

the discharge being in pounds per second, p in pounds per square inch, A in square inches, and T in deg. Fahr. absolute.

$\therefore$ the discharge coefficient c

$$= \frac{v}{R\,T}\,b\,p \div 0.534\,\frac{p\,A}{\sqrt{T}} = \frac{v}{0.534\,R} \times \frac{b}{A\,\sqrt{T}} \quad . \quad (3)$$

Experiments made at different times showed that ordinary variations of atmospheric temperature and humidity had no appreciable effect on the discharge.

Accuracy of Discharge Coefficients.—The experimental factors to be determined were v, A, T, and b. The volume v was found by filling the reservoir with water and then running the water into a tank, in which it was weighed. The error is negligible. To measure A, cylindrical gauges were made, ground to fit the throat of the nozzles and measured by a micrometer. It is difficult to determine the diameter to a closer degree than 0.001 in., which implies a possible error in the area of 1 per cent.

The mean temperatures used in most of the calculations are certainly within 1 deg. Fahr. of the actual temperatures during the latter part of the flow, so that the error in the square root of T is not more than 0.1 per cent. In some cases T was assumed from the atmospheric

Fig. 5. IMPACT APPARATUS.

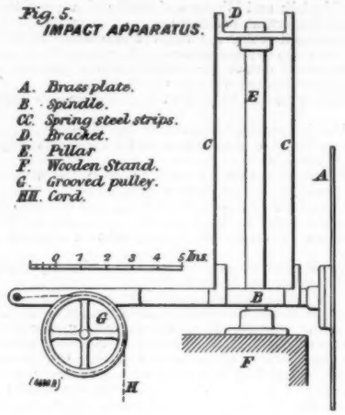
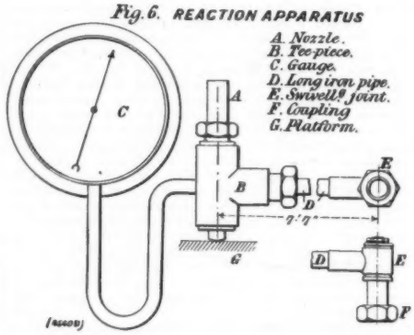


Fig. 6. REACTION APPARATUS



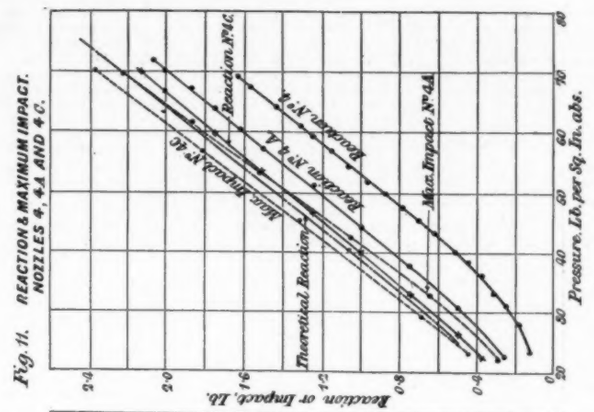
temperature and from the temperature drop usually observed in previous experiments; even in this case $\sqrt{T}$ is correct to 0.3 per cent. The slope b of the curve of log p and t depends chiefly upon the accuracy of the readings of the pressure-gauge. It could be relied upon to 0.5 lb. per sq. in., and in view of the closeness of the experimental points to the straight-line graph and the consistency of repeated experiments, b may be taken as correct within 1 per cent. certainly. Hence the error in the coefficient of discharge cannot exceed 2·5 per cent. at most, and probably does not exceed 1 per cent. Errors in the area A do not affect the discharge (see equation 2), which is therefore correct within less than 1 per cent.

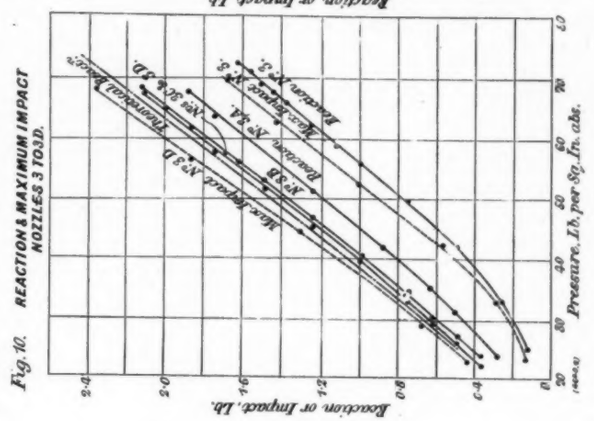
Measurement of Velocity.—The methods of measuring the velocity of the air-jets that were considered were (*a*) the Pitot tube, (*b*) measurement of the reaction, and (*c*) measurement of the impact of the jet upon a surface of known form, the most suitable surface being a flat plate placed normally to the jet, and large enough to ensure that the air should leave the plate tangentially.

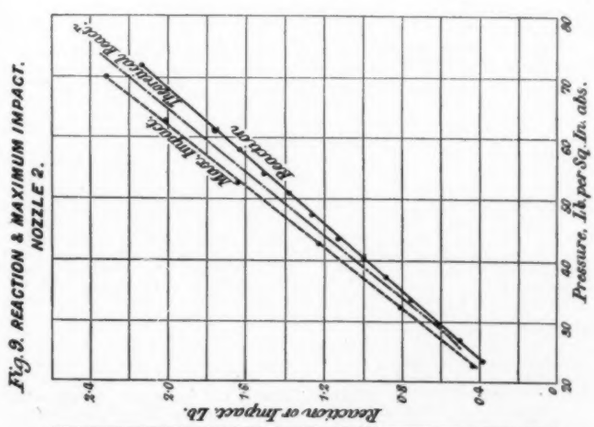
In comparing these methods it was always kept in mind that the mean or "effective" velocity of the jet was the object aimed at—that is, the measure of the effectiveness of the jet for employment in, say, a compressed-air turbine or for jet propulsion by reaction. The Pitot tube would afford a means of determining velocities at certain points in the jet only, and on account of the small size of nozzles that was practicable, a complete survey of the distribution of velocity would be exceedingly difficult. There would also arise the question of the standardisation of the Pitot tube for velocities up to 1600 ft. or 1800 ft. per second. Also, in calculating the velocity from the readings of the Pitot and the pressure tubes, it is necessary that the density of the fluid in the jet should be known; the temperature must therefore be known, but the measurement of the temperature of a jet in rapid motion presents great difficulties. The impact method was at first adopted, but in view of the differences discovered when the plate was at varying distances from the nozzles, the reaction method was also employed.

Impact Apparatus.—The apparatus used for the determination of the impact of the jet is illustrated in Fig. 5, above. A brass plate A, 12 in. in diameter, was fixed centrally at right angles to a spindle B. B was carried by two parallel flat strips of thin spring steel C C clamped at their upper ends to a bracket D on a pillar E, which was screwed to a wooden stand F. A grooved pulley G was mounted by delicate pivot-bearings on a bracket also fixed to the stand F. From an extension of

THE FLOW OF AIR THROUGH NOZZLES.







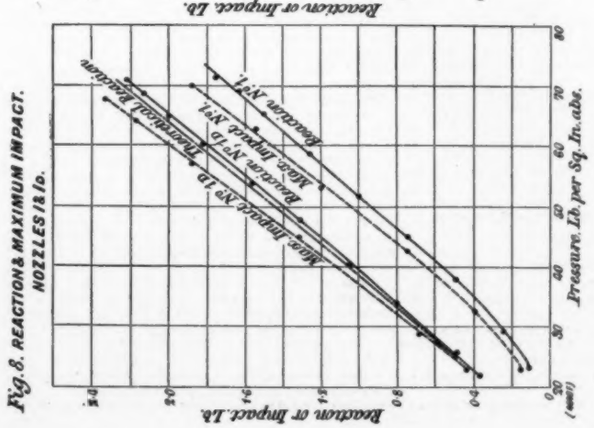
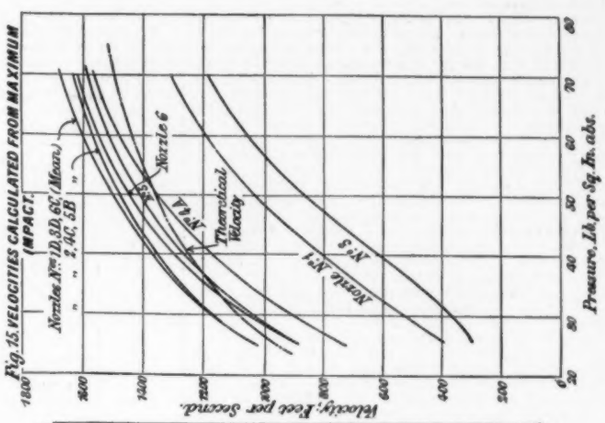
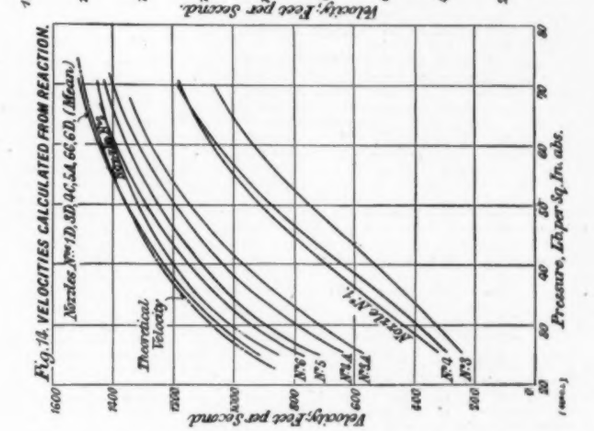


Fig. 8. REACTION & MAXIMUM IMPACT. NOZZLES 1 & 1D.
Reaction or Impact, Lb.
Pressure, Lb. per Sq. In. abs.
Max. Impact N°1D.
Reaction N°1D.
Max. Impact N°1.
Reaction N°1.
Theoretical Reaction.





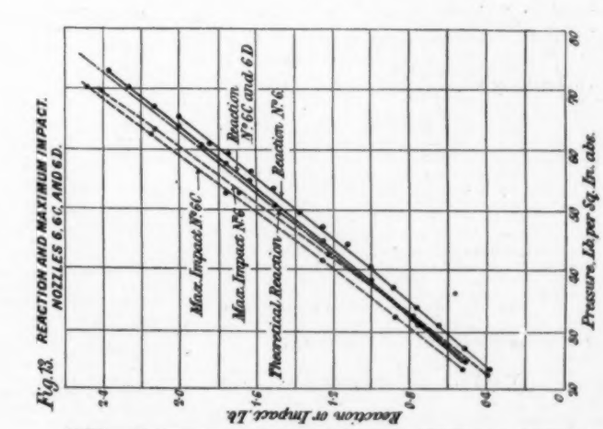
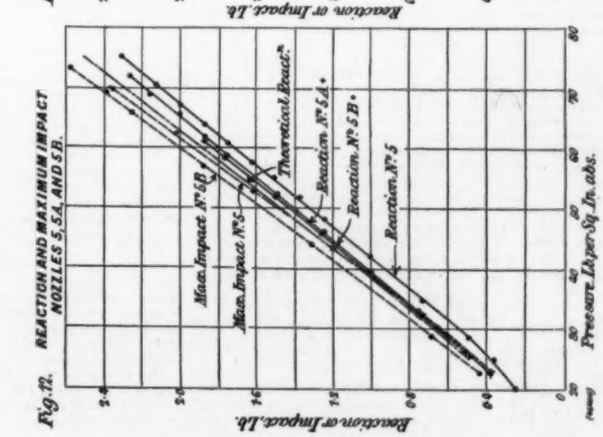


Fig. 13. REACTION AND MAXIMUM IMPACT. NOZZLES 6, 6C, AND 6D.
Reaction or Impact, Lb.
Pressure, Lb. per Sq. In. abs.
Max. Impact N°6C.
Reaction N°6C and 6D
Max. Impact N°6.
Reaction N°6.
Theoretical Reaction.



the spindle B a cord H H passed in a direction normal to the plate A, then over the pulley G, and carried at its lower end a scale-pan.

The spindle B was limited in movement by stops (not shown in the figure). The air-nozzle being horizontal, as shown in Fig. 2, page 92, the impact apparatus was placed so that the jet would impinge normally at the centre of the plate A. The zero was adjusted by placing weights on the scale-pan until the spindle swung just clear of its stops. Extra weights were then added, the air allowed to flow, and the pressure in the reservoir was noted when the spindle again just cleared the stops in the same manner as before. A dash-pot below the scale-pan served to limit oscillations of the apparatus.

Reaction Apparatus.—To measure the reaction of a jet, it is necessary to have a flexible or a swivelling connection between the nozzle and the source of the air-supply. In order to avoid the difficulty of making a joint which should be reasonably air-tight and yet nearly frictionless, experiments were made with canvas hose as the flexible connection, then with an iron tube and a short length of hose to give flexibility at one point only, and then with a fixed horizontal pivot added to the latter arrangement as near the flexible connection as possible.

None of these was influenced by friction (except for a very slight friction in the last named), but they all suffered from the defect that they were deflected from their zero position by changes of pressure of the air in the connecting pipes, and as this deflection was different for all pressures, and liable to accidental variations as well, it was impossible to separate accurately the effects of pressure and of reaction.

The apparatus which was finally adopted, and which gave very satisfactory results indeed, is shown in Fig. 6. The nozzle A was coupled to a T-piece B which served as a small air-receiver, the pressure being indicated by the gauge C. The T-piece B was connected by a long iron pipe D, swivelling-joint E, and coupling F to the large air-reservoir. The T-piece B, with its attachments, rested on the platform G of a small weighing-machine, and the apparatus was set so that the axis of the nozzle was vertical when in the balanced position. A long, light pointer was fixed to the beam of the weighing-machine to indicate its movements, and a definite position of balance was ensured by attaching to the platform of the weighing-machine a light spring fixed at its upper end to a bracket which could be raised or lowered by a screw. After the weight of the apparatus had been approximately balanced, this screw was adjusted so that, on raising the platform G and gently releasing it, the pointer came to a marked position. Weights were then placed on the scale-pan of the weighing-machine, thus again raising G, and a cock situated between the air-reservoir and the coupling F was carefully opened until the pointer just returned to its zero position, when the reading of the gauge C was noted. In this way it was ensured that the friction at the swivel-joint E would influence both the zero reading and the reading during a test in the same way. The zero was again checked after the reading had been taken. On account of the length of the pipe D, the influence of friction at the joint E was very small, and it was found also to be very constant, so that it is safe to regard friction effects as completely eliminated by the method of working described.

Calculation of Velocity.—The reaction of the jet

$$= \frac{d\,m}{d\,t} V = \frac{F}{g} = F, \text{ say,}$$

$$\therefore \text{ velocity } V = \frac{F\,g}{\frac{d\,m}{d\,t}} = \text{(from equation (2))} \frac{R\,T\,F\,g}{v\,b\,p}.$$

For purposes of comparison, it is convenient to calculate the velocity for an initial air-temperature of 60 deg. Fahr.; the "reduced" value of V thus becomes

$$\frac{R\,T\,F\,g}{v\,b\,p}\sqrt{\frac{520}{T}} = k\frac{F\sqrt{T}}{v\,b\,p} \text{ where } k \text{ is a constant.}$$

Taking $v = 46.9$ cub. ft., and F in pounds,

$$V = 150.5\frac{F\sqrt{T}}{b\,p} \text{ feet per second.} \quad . \quad (4)$$

According to the ordinary theory, the effects of temperature on the discharge and on the velocity are inverse, so that the theoretical reaction is independent of temperature. Experiments carried out at different times showed that the actual impact and reaction were not affected by atmospheric changes of temperature. This applies also to changes of humidity.

Accuracy of Impact, Reaction, and Velocity Results.—Both the impact and the reaction appliances were very sensitive, indicating with care to 0.2 oz. The chief observational error in these experiments was due to the pressure-gauge, which could only be read to 0.5 lb. per sq. in. Comparing the change of impact or of reaction corresponding to this with that being measured, and considering the sensitiveness of the apparatus, it is concluded that the impact and reaction results are, on the whole, correct within 1.5 per cent. at pressures of about 70 lb. per sq. in., and within 5 per cent. at 30 lb. per sq. in.

The impact results do not agree with the reactions within these limits; but this difference is not due to errors of observation in experiments, and it is discussed in Section II. of the paper.

The velocities calculated from the experimental data depend upon F, $\sqrt{T}$, b, and p in equation (4) (The volume v which is included in the constant 150.5 is taken as correct.) Hence, due to observational errors only, the error in V at 70 lb. per sq. in. is less that 3 per cent., and at 30 lb. per sq. in. is less than 6 per cent.

QUANTITATIVE RESULTS OF EXPERIMENTS.

Discharge.—A number of typical graphs of log p and t are shown in Fig. 4 (page 92), and Table II. contains the discharge coefficients for all the nozzles tested.

Since the discharge coefficient for each nozzle was found to be constant, the actual discharge values need not be tabulated. They can be easily found by multi-

TABLE II.—*Discharge Coefficients.*

Nozzle. (See Fig. 1.)	Cross-Section at Throat.	Slope b of Log Graph.	Mean Absolute Temperature.	Discharge Coefficient.
	sq. in.		deg. F.	
1	0.0294	0.0704	516	0.96
1D	0.0294	0.0702	508	0.97
2	0.0289	0.0695	513	0.97
3	0.0298	0.0701	516	0.95
3D	0.0298	0.0707	508	0.96
4	0.0292	0.0690	515	0.95
4A	0.0292	0.0699	518	0.96
4C	0.0292	0.0706	513	0.97
5	0.0300	0.0730	518	0.975
5B	0.0300	0.0730	513	0.98
6	0.0302	0.0734	514	0.98
6C	0.0302	0.0734	512	0.98

plying the "theoretical discharge per unit area of nozzle," as shown in Table III. (below), by the nozzle area, and by the discharge coefficient as shown in Table II.

The coefficients for a particular nozzle and those derived by cutting it down can be compared with greater accuracy than those for entirely different nozzles, since errors in the measurement of the throat areas do not affect the former comparison. As was to be expected, the shortening of the nozzles leads to a slight increase of the discharge coefficient. That this increase is not entirely due to the reduction of the wall surface, and consequent reduction in friction at that surface, but depends also on the taper, is evident from the results obtained with nozzles 5 and 6, which were nearly parallel, and which, after being cut down to 5B and 6C, had practically the same discharge coefficient as before. The relatively low coefficients for nozzles 1, 3 and 4 are due to over-rapid divergence after the throat, which causes shock losses and resistances, which raise the pressure at the throat.

The influence of the entrance curves of the nozzles, about 0.1 in. radius in nozzles 4 and 5, 0.5 in. in nozzles 1, 3 and 6, and a relatively very long entrance in nozzle 2,

TABLE III.—*Theoretical Discharge per Unit Area of Nozzle.*

(Temperature 60 deg. Fahr. or 520 deg. Fahr. absolute.)

Pressure. Lb. per Sq. In.	Discharge. Lb. per Second per Sq. In.	Pressure. Lb. per Sq. In.	Discharge. Lb. per Second per Sq. In.
75	1.752	45	1.052
70	1.638	40	0.936
65	1.520	35	0.820
60	1.403	30	0.702
55	1.285	25	0.581
50	1.169		

can be best examined by reference to the results obtained with nozzles 1D, 2, 3D, 4C, 5B and 6C, for all of which the divergent part has been completely, or almost completely, removed, although, for the reason already stated, these results cannot be so accurately compared as those for nozzles having the same throat.

The maximum difference in the coefficients for these nozzles is 2 per cent., which is within the limit of possible experimental error. It is quite probable that nozzle 3D has really a lower coefficient than the others, since it had a perceptibly sharp change of curvature at the throat which would set up a *vena contracta* in the stream of air. Excluding nozzle 3D from the comparison, the maximum difference in the coefficients is 1 per cent., so that it may be concluded that the various entrance curves have no appreciable effect upon the coefficients.

Impact and Reaction.—It was noticed that the impact of an air-jet upon the flat plate varied as the distance of the plate from the nozzle was altered, and accordingly a series of tests were made at constant pressures of 62.6, 52.6, 42.6, and 32.6 lb. per sq. in. in order to determine the amount of this variation, and in particular to find the maximum value of the impact.

The results of the experiments at 62.6 and 32.6 lb. per sq. in. are shown in Fig. 7. In order to eliminate the effect of differences in the nozzle areas, and so to facilitate the comparison of the results, the impact is in all cases "reduced" to a common nozzle area of 0.03 sq. in. —that is, the actual impact is multiplied by $\frac{0.03}{\text{nozzle area}}$.

The curves show a general similarity, and the impact attains its maximum at a distance of about 8 in. from the nozzle. In some cases the maximum occurs at 6 in. and in some at 10 in. distance, but the change in its value between these points is small. Hence, when the maximum at other pressures was required, only a few distances in the neighbourhood of 8 in. were tested.

The probable cause of the variation of the impact is discussed in Section II.

The values of the reaction and of the maximum impact are shown plotted upon a base of pressures in Figs. 8 to 13, page 93. The curves for some of the intermediate nozzle forms have been omitted in order to avoid confusion. The full lines represent reaction, the dotted lines maximum impact, and the chain-dotted lines the "theoretical" reaction. Most of the curves are nearly straight except at pressures below about 35 lb. (or, in the case of nozzle 3, 45 lb.) per sq. in. Of the results not shown in the figures, the reactions for nozzles 1B and 1C, which are the same, are 0.02 lb., and for 1A 0.125 lb. below those for 1D; 4B, from being 0.03 lb. below 4C at 30 becomes slightly above 4C at 70 lb. per sq. in.; 6B is 0.02 lb. and 6A is 0.06 lb. below 6C. As a rule, reducing the length of the divergent nozzles greatly increases their efficiency, although this reduction has apparently been carried too far in the case of nozzle 5B, which gave a lower reaction than 5A.

Velocity.—The velocities calculated from the experimental data are shown in Figs. 14 and 15, page 93, Fig. 14 corresponding to the reactions, and Fig. 15 to the maximum impacts. In Fig. 14 the results for nozzles 1D, 3D, 4C, 5A, 6C, 6D are shown by a single curve representing their mean, with which each nozzle agrees within the limits of experimental error. The relative order of merit of the nozzles, as indicated by both figures, is practically the same. Nozzles 1 and 3 differ only slightly in contour, but the effect upon the efficiency is very marked, nozzle 3 being much inferior. Comparing nozzles 1 and 4, or 5 and 6, the divergent parts of which are about the same in length and taper, it is evident that the nozzle with the larger inlet curve gives the higher velocity, though the difference is not great.

The nozzles with the rapid taper are much less effective than Nos. 5 and 6, in which the taper is gradual. This is to be expected from theoretical considerations, for on calculating the dimensions of a nozzle for initial and final pressures of, say, 73.5 and 14.7 lb. per sq. in. respectively, it is found that the ratio of the area at the outlet to that at the throat should be 1.33, so that if the throat diameter is 0.196 in., the outlet diameter should be 0.226. In the case of nozzle 6, this diameter occurs when the length is 2.4 in., but in the case of nozzle 1 the same ratio of areas is reached when the length is 1.2 in., and for nozzle 4 when the length is 0.6 in. The experiments show that the best results are obtained when the nozzles are even shorter than these lengths; also the comparative efficiency of the nozzles over a very considerable range of pressure seems to be independent of the pressure.

According to the theory, one should expect the shorter nozzles to be the best for low pressures, but that at higher pressures rather longer nozzles, of the same taper, should be the best. The range of pressures available in the experiments was too limited to permit of full investigation of this point; but so far as the tests go, the nozzle which is better than another of the same group—that is, having the same throat and same taper—at one pressure is found to be better at all pressures. The only indication of an exception to this is furnished by nozzles 4B and 4C, the reaction curves for which cross at a pressure of 55 lb. per sq. in.; the effect is very slight, however, and may be due to experimental error. Naturally, as the nozzles are cut shorter and shorter, the effect of different degrees of taper is diminished, and the results for all the nozzles tend to agree as they approach a simply convergent form, though, since nozzle 5B gave a slightly lower reaction than 5A, it seems that a certain amount of divergence may be desirable. Nozzle 2, which is entirely convergent, is too long, giving a lower reaction than the others when they are cut down to their best proportions; this lower efficiency is not so marked in the impact results.

Considering now the absolute values of the velocities obtained with the best nozzle forms, it will be seen that those based upon the reactions are practically equal to the theoretical values, while the impact experiments lead to figures some 12 per cent. higher. The accuracy of the experiments has already been discussed. The discrepancy in the results of the two methods forms the subject of a separate investigation which is described in Section II., and from which it appears that the velocity calculated from the reaction is correct. The efficiency of the best nozzle forms is thus practically unity.

(To be continued.)

WORKERS' HOMES IN AUSTRALIA.—In several of the Australian States, says the High Commissioner for Australia, there are systems established by the Government under which workers may obtain from the Government financial assistance in order to enable them to secure homes on easy terms. The system has been a great success. Many have in this way been able to free themselves from the landlords and to establish comfortable homes, paying off the amount advanced by the Government under easy conditions. In South Australia the first Act dealing with the establishment of workers' homes was passed in 1910, and in order to get a loan under the Act the applicant had to possess either land on which he proposed to build, or else cash to the amount of at least one-fifth of the cost of the dwelling and the land. An amendment has now been proposed, which provides that the board of trustees of the State Bank might purchase land at the request of a person who desires to build, but is unable to do so without special assistance. A deposit of 3*l.* has to be made by the applicant to prove his *bona fides* in the matter, and the sum is to be forfeited if, after the land has been purchased, he refuses to enter into an agreement with the board to buy it. The trustees have to be satisfied, among other things, that the applicant has been in employment for at least 200 days in each of the three years immediately preceding the making of the request, with a view to ensure that the benefits of the Act should not be taken advantage of by loafers.